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Is There a High Rice Price Volatility in the Philippines: Insights from Bayesian Seasonal Autoregressive Distributed Lag (BARDL)

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ABSTRACT: This paper analyzes the high volatility in rice prices in the Philippine market from October 1994 to April 2024 using a Bayesian seasonal autoregressive distributed lag (BARDL) model with three lags. Using a dataset of 160 observations, this model controls for lagged prices and seasonal effects that showed significant persistence in rice prices through the first lag, market corrections through the second lag, and minimal impacts from seasonality. Model diagnostics, including WAIC and LOOIC, indicate the model's goodness but show considerable unseen variability σ, and external factors seem to be prevailing. The findings thereby emphasize the failure of using market mechanisms to stabilize prices and the crucial need for strategic government interferences. It discusses market failure effects, the pendulum approach to economic policy, and welfare economics, urging for a balanced approach that combines market intervention with more supportive policies toward farmers to stabilize the rice market.

KEYWORDS: Market Failure, Government Intervention, Rice Price Volatility, Bayesian ARDL, Food Security

I. INTRODUCTION

The effectiveness of market mechanisms and government policies in stabilizing rice prices (Dawe & Timmer, 2012) in the Philippines has been a contentious issue, particularly following the government's decision to impose a price cap on rice in September 2023 (DA-AFID, 2023). This move was intended to protect consumers from soaring prices (Rapisura, 2023), which had reached alarming levels due to various factors, including global supply chain disruptions (Jamille, 2024) and domestic production challenges (Gomez, n.d.). However, implementing this price cap raised questions concerning its practical applicability and resulting impact on the rice market (Rivera, 2023).

Through Executive Order No. 39, the government pegged its price cap at ₱41 per kilogram for ordinary milled rice and at ₱45 per kilogram for well-milled rice (DA-AFID, 2023). The government, with President Ferdinand Marcos Jr., said the move helped stabilize prices between ₱47 and ₱57 per kilogram (News, 2023). News reports show that the price cap reduced inflation slightly; year-on-year inflation fell to 6.1% in September 2023, partly due to this move (Summary Inflation Report n.d.). However, while the price cap aimed to provide immediate relief to consumers, it also raised concerns about its long-term sustainability and potential adverse effects on local farmers (Rivera, 2023).

Despite its short-term consumer benefits, the price cap created significant challenges for local rice producers, leading to capping prices below market equilibrium, thus reducing incentives to produce rice (Rivera, n.d.). Farmers feared this would reduce agricultural output in subsequent seasons (Atienza, 2023). The National Food Authority (NFA) has long been involved in the rice market to stabilize prices, but its effectiveness is in question (September Inflation Rises, 2019). Studies show that although government interventions can level out producer prices, wholesale prices are not controlled as effectively (Jamille, 2024, November 15), especially when external factors such as global supply shocks are concerned. Furthermore, the imposition of price ceilings resulted in hoarding and supply shortages (Flores & Lema, 2023) due to reports of retailers changing their inventory strategies to offset losses arising from selling at capped prices (Ramos, 2023).

According to Agriculture Secretary Francisco P. Tiu Laurel Jr., this manifests a more profound problem of market mechanisms in which the price control mechanism has the opposite effect of creating scarcity rather than stabilizing (Philippines Sep Rice, 2023). In contrast, lower tariffs on imported rice were implemented to reduce the retail price (Jamille, 2024), and high prices in the market prevailed, considering wholesale cost discrepancies and retail pricing practices (Panti, 2024).

This move, however, came with the lifting of the price cap in October 2023, a recognition of these complexities within the rice market (Mangaluz, 2023). Government officials said that the necessary assistance programs would continue for affected sectors. Still, it was apparent that reliance on price controls alone was insufficient to solve the problems plaguing rice production and distribution (Doliente & Samsatli, 2021). The Rice Tariffication Law was enacted to liberalize the market and enhance competitiveness (Tobias, 2019); however, it has also exposed vulnerabilities within local agriculture that require more comprehensive policy support (OPINION, 2019). Experts recommend investments in agricultural infrastructure, technology adoption, and targeted support for small-scale farmers to foster a more stable rice market (Mariano et al., 2012).

These measures are essential to increase productivity and ensure local farmers compete effectively against imported rice without relying on artificial price controls (Office, 2024). The Philippine Rice Industry Stakeholders Movement (PRISM) emphasizes the need for a safety net program that includes subsidies for seeds and fertilizers to safeguard farmers' livelihoods amid fluctuating market conditions (Carretero, 2023). Although the government placed a price cap on rice to help the consumers who were facing increasing costs immediately, it indicated deep problems in the proper function of market mechanisms and policies in stabilizing the price (Rivera, 2023).

Government interventions and market dynamics exposed short-term benefits and long-term challenges, calling for a more holistic approach to agricultural policy (Poulton et al., 2006). Addressing these complexities will be essential for achieving sustainable food security and economic stability in the Philippine rice market in terms of long-term implications (Mariano et al., 2012). Between 2010 and 2024, the Philippine government implemented several policies and programs to stabilize the rice market, aiming to balance consumer affordability with farmer profitability (Rice – Industry Strategic, n.d.)

Until 2019, the NFA took center stage in ensuring rice price stability by controlling imports, maintaining buffer stocks, and even interfering in the market to manipulate supply and pricing (Office, 2024). Its mandates included buying palay (unhusked rice) from local farmers at support prices and selling milled rice to consumers at subsidized rates. This approach was, however, criticized for inefficiencies and alleged rent-seeking behaviors (Office, 2021).

The government responded to rice shortages and price surges by passing Republic Act No. 11203, the Rice Tariffication Law, in 2019. This law replaced quantitative import restrictions with tariffs, allowing private traders to import rice more freely, subject to a 35% tariff for ASEAN countries. The RTL aimed to increase supply, reduce prices, and encourage competition (Balié et al., 2021). It also established the Rice Competitiveness Enhancement Fund, which allocated tariff revenues to support farmers through mechanization, seed development, credit assistance, and training (LawPhil, n.d.).

The Free Irrigation Service Act of 2018 was created to lower production costs for farmers, with a free irrigation service fee payment to small owners with eight hectares of land. This law sought to improve productivity and raise incomes by easing a high-cost component of rice farming (FAO.org., n.d.). The Sagip Saka Act of 2019 was instituted to enhance the development of enterprises among farmers and fisherfolk for higher income generation and direct farm-to-table procurement (PRRD Signs into, 2019). Its objective is to empower the farmers by having better market access and fewer layers of intermediaries for stabilized prices for producers and consumers (Roy, 2019).

The government revived the Kadiwa program, which was started during the time of President Ferdinand Marcos, allowing farmers to sell their harvest directly to consumers. Such a program would help farmers lower agricultural product prices by allowing fewer intermediaries in the supply chain (What is the KADIWA, 2024). Aware of the strategic need for stable rice imports, the Philippines sought to strengthen cooperation with major rice-exporting countries. In 2024, the government planned to enhance rice cooperation with Vietnam in the face of growing domestic demand due to population growth. This cooperation involved urging Vietnamese rice companies to invest in the Philippines. It was in line with agreements on rice trade and agriculture cooperation reached during President Ferdinand Marcos Jr.'s state visit to Hanoi in January 2024. These policies and programs reflect the government's multifaceted approach toward stabilizing the rice market, both supply-side and demand-side factors, to attain food security and economic stability (Reuters Staff, 2024).

The present study primarily advocates for the United Nations Sustainable Development Goal No. 2: Zero Hunger. The research on the balance between market freedom and government intervention in the Philippine rice market addresses critical areas of food security, price stability, and resource equitability. The findings and recommendations are intended to ensure stable supplies of affordable rice, support farmers' livelihoods, and enhance the resilience of the agricultural sector. These efforts contribute to ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture- all central to UNSDG no. 2.

This study aims to investigate the determinants of rice prices in the Philippine market, particularly by gaining insight into the time dynamics and volatility of the price. It considers the lagged effect of past prices and seasonal factors to determine persistence patterns, market corrections, and the general stability of rice prices. Furthermore, it seeks to unravel some factors that lead to price variability in terms of insights into market mechanisms and policy interventions for stabilizing rice prices, making it affordable to consumers while supporting rice farmers' livelihoods.

II. THEORETICAL FRAMEWORK

In many respects, this paper attempts to study balancing market freedom and government control in the rice market of the Philippines using several economic and political theories. Among the relevant theories is the Theory of Market Failure (Nedergaard, 2006). According to this theory, markets, left to themselves, can fail to make the best allocation of resources for several reasons, such as externalities (Santos, 2000), public goods (Rocha, 2007), and information asymmetries (Ullah et al., 2020). In the context of the rice market, government intervention is often justified to correct these market failures and ensure that consumers and farmers are protected from the adverse effects of price volatility and supply shortages (Winston, 2007).

Government Intervention occurs when the free market fails to produce socially optimal outcomes (Stiglitz, 2010), manifesting in the rice market as price volatility, harming consumers and farmers (Naylor & Falcon, 2010). For instance, when there are low supplies, rice prices tend to shoot up, making it difficult for consumers to acquire this staple food. Conversely, if there are high supplies, prices might plummet, reducing the incomes of the producing sectors to potentially distressing levels. Government interventions, including price caps, subsidies, and import controls, have been developed to address the problems of stabilizing prices and guaranteeing a reliable supply (Murphy et al., 2019).

The Pendulum Theory of Economic Policy also describes the tendency for economic policy to oscillate between times of greater liberalization and more government interference (Kuo, 2007). This theory is particularly relevant in the Philippines, where policy shifts have alternated between liberalization and intervention (Link, 2018). For example, the Rice Tariffication Law (RTL) 2019 marked a significant change toward market liberalization by replacing quantitative restrictions on rice imports with tariffs (Kim, 2011). However, subsequent calls to restore the National Food Authority's (NFA) market intervention powers reflect a swing towards greater government control in response to market instability.

Welfare Economics, another theoretical approach that best suits this paper is concerned with maximizing social welfare through the most optimal and efficient allocation of resources (Mishan, 2013). In the rice market, welfare economics supports government policies that enhance the distribution and allocation of resources in terms of reducing inequality and meeting food adequacy (Naert, 2021). Other policies, such as the Rice Competitiveness Enhancement Fund (RCEF), are meant to provide support for farm mechanization, seed development, and credit assistance, aiming to improve farmers' welfare and ensure a stable supply of rice for consumers (Antle, 2015).

The interaction between market freedom and government control in the rice market of the Philippines can be understood using the lenses of market failure, the pendulum theory of economic policy, and welfare economics. These theories underscore the government's balanced use of market mechanisms and interventions to provide price stability, equity, and long-term food security. Understanding these theoretical models helps policymakers formulate an effective strategy for facing these challenges in the rice market.

III. METHOD

The study used the Bayesian Seasonal Autoregressive Distributed Lag (BARDL) model with three lags to determine the presence of high price volatility in the Philippines from October 1994 to April 2024. The Bayesian ARDL approach was chosen due to its robustness in capturing both short-term dynamics (Salakpiet al., 2022) and long-term equilibrium relationships (Zang et al., 2023) in time series data while accounting for prior uncertainty in the parameter estimates (Sun et al., 2024). Further, including seasonal components allowed the model to address potential periodic patterns in rice prices, a critical aspect of agricultural markets.

The dataset is composed of monthly rice prices, covering nearly three decades. The dependent variable was the current price (P_t), while the independent variables included lagged rice prices $(P_{t-1}, P_{t-2}, P_{t-3})$, seasonal dummy variable (S), and an error term (ε_t). The inclusion of lagged variables intended to capture temporal price persistence, market corrections, and external shocks, while the seasonal terms accounted for cyclical price patterns.

The ARDL model used in this study is expressed as:

$$P_t = \alpha + \beta_1 P_{t-1} + \beta_2 P_{t-2} + \beta_3 P_{t-3} + \sum_{i=1}^{m} \gamma_i S_i + \varepsilon_t$$

Where: P_t, current rice price; P_{t-i}, lagged rice prices $(i = 1, 2, 3)$; S_i, seasonal dummy variables $(i = 1, 2, \ldots, m)$; $\beta_1, \beta_2, \beta_3$; coefficient of lagged variables; γ_i, coefficient of seasonal variables; α, intercept term; ε_t, error term.

The Bayesian framework incorporated prior distributions for the model parameters (β, γ, α), facilitating parameter estimation that integrates prior knowledge with observed data. Posterior distributions were derived using Markov Chain Monte Carlo (MCMC) simulations, ensuring robust inference even with complex model structures.

This conceptual framework in Figure 1 shows a Bayesian ARDL model with three lags and seasonal components where the current price, y_t, is influenced by its three previous values, y_{t-1}, y_{t-2}, and y_{t-3} and quarterly seasonal effects Q_2, Q_3, Q_4 with Q_1 as reference. The Bayesian aspect is represented by incorporating prior distributions for the model parameters, including the β coefficients and σ error term, that combine with the data likelihood to form posterior distributions via MCMC sampling. It clearly shows how all these components interplay with one another. That is, lagged and seasonal variables feed into the current price prediction, and the prior distributions feed into the MCMC estimation process to produce posterior distributions, convergence diagnostics, and predictions. In essence, MCMC captures the iterative nature of a feedback loop between a posterior distribution and MCMC sampling, as how the estimates improve through many iterations to eventually achieve convergence.

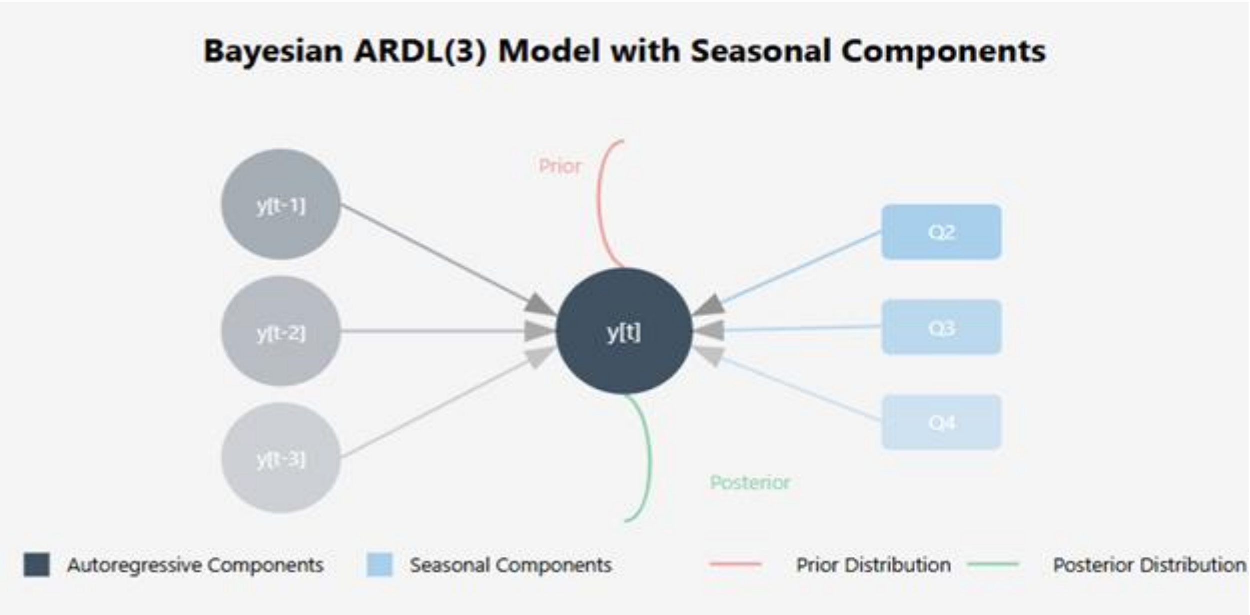

Figure 1. Conceptual Framework of the Method

IV. RESULT AND DISCUSSIONS

This study aims to explore and model the dynamic behavior of rice price volatility using a Bayesian approach based on the Autoregressive Distributed Lag (ARDL) framework with seasonal components. It attempts to identify the effects of price movements over time, seasonal variation at a quarterly frequency, and other factors on the current prices of rice while taking advantage of Bayesian inference to embed prior information and produce posterior estimates of robust inferences. It attempts to explain the mechanisms behind the rice price variations by incorporating lagged price effects and seasonal trends. It aims to determine the high price volatility in the rice markets.

Descriptive statistics for rice prices from September 2010 to April 2024 have essential information about price distribution over the period. The mean price is approximately 22,570.86, while the median is slightly lower at 22,034.43, suggesting that the distribution is right skewed, as shown by the skewness value at 1.41. The standard deviation at 4,078.90 and a range 20,254.47 reveal considerable price variation. The sample variance is very high at 16,637,426.17, again underscoring this variability. The kurtosis value is 2.53, meaning the distribution has heavier tails than a normal distribution, indicating occasional extreme price changes. The minimum and maximum prices reported are 16,686.86 and 36,941.33, respectively, depicting the considerable fluctuation in rice prices during the analysis period. These statistics collectively suggest that while the average rice price has been around 22,570.86, there have been significant fluctuations and occasional extreme values.

Table 1. Rice Price Descriptive Statistics

Rice Price	
Mean	22570.86
Standard Error	318.5086
Median	22034.43
Standard Deviation	4078.9
Sample Variance	16637426
Kurtosis	2.526142
Skewness	1.412223
Range	20254.47
Minimum	16686.86
Maximum	36941.33

This time series graph in Figure 2 depicts the past rice prices between September 2010 and April 2024 and reflects many market patterns and trends. The price trajectory is broadly split into distinct phases: the initial phase was relatively stable, fluctuating around 20,000-25,000 between 2012 and 2014; then, the prices gradually moved into a lower range of 15,000-20,000 between late 2014 and 2017. The market entered a phase of gradual recovery and increased volatility from 2017 to 2020, during which time prices generally went up but significantly fluctuated. The sharp rise in volatility starting from 2020 could be linked to global events as the prices showed dramatic swings between 20,000 and 28,000. The most significant shift occurs in the final period between 2023 and 2024, where the price curve rises dramatically, showing an upward trend and touching the unprecedented level of around 35,000-37,000, which marks the highest point of the dataset. This recent sharp increase indicates massive market disruptions or fundamental changes in supply and demand dynamics in the rice market during this period.

Figure 2. Rice Price from September 2010 to April 2024

The results from the Augmented Dickey-Fuller (ADF) and KPSS tests in Table 2 indicate that the dataset is stationary. The ADF test statistic of -9.856345 is significantly lower than the critical values, and the p-value is extremely small (4.349246e-17), suggesting strong evidence against the null hypothesis of a unit root, thus confirming stationarity. On the other hand, the KPSS test statistic of 0.229245, with a p-value of 0.100000, does not provide sufficient evidence to reject the null hypothesis of stationarity. These results strongly suggest that the time series data is stationary, meaning its statistical properties, like mean and variance, are constant over time.

Table 2. Augmented Dickey-Fuller (ADF) and KPSS tests

	ADF Test	KPSS Test
Test Statistic	-9.85635	0.229245
p-value	4.35E-17	0.1
#Lags Used	1	6
Number of Observations Used	161	NaN

The results of the Bayesian ARDL model with three lags of rice prices and seasonal effects in Table 3 provide several insights based on Regression Coefficients. The intercept estimate is 47.99, with a standard error of 174.89. The 95% credible interval ranges from -290.28 to 394.98. This broad interval indicates a high degree of uncertainty around the intercept, suggesting that the baseline level of rice prices, when all other variables are zero, is not precisely estimated. The coefficient of Lagged Rice Price 1 (lag_rice_price_1) is 0.16 with a standard error of 0.08. The 95% credible interval ranges from -0.00 to 0.31. Although the interval includes zero, the positive estimate suggests a potential small positive effect of the first lagged of rice prices on current prices, indicating some persistence in rice prices over time.

Table 3. Bayesian ARDL model with three lags of rice prices and seasonal effects

Parameter	Estimate	Est. Error	l-95% CI	u-95% CI	Rhat	Bulk_ESS	Tail_ESS
Intercept	47.99	174.89	-290.28	394.98	1	3447	2870
lag_rice_price_1	0.16	0.08	0	0.31	1	5367	3122
lag_rice_price_2	-0.17	0.08	-0.33	-0.01	1	6091	3300
lag_rice_price_3	-0.04	0.08	-0.2	0.13	1	5800	2976
seasonQ2	1.55	245.1	-466.87	484.64	1	3580	3449
seasonQ3	154.63	246.01	-324.23	632	1	3680	3300
seasonQ4	-76.16	248.81	-564	415.49	1	3835	3524
sigma	1085.15	64.44	968.02	1218.19	1	5982	3217

With Lagged Rice Price 2 (lag_rice_price_2), the coefficient is -0.17 with a standard error of 0.08. The 95% credible interval ranges from -0.33 to -0.01, which does not include zero. This indicates a statistically significant negative effect of the second lag of rice prices on current prices, suggesting that higher rice prices two periods ago are associated with lower current rice prices. In Lagged Rice Price 3 (lag_rice_price_3), the coefficient is -0.04 with a standard error of 0.08. The 95% credible interval ranges from -0.20 to 0.13, which includes zero. There is no firm evidence of an effect of the third lagged of rice prices on current prices.

For Seasonal Effects in Season Q2, the coefficient is 1.55 with a standard error of 245.10. The 95% credible interval ranges from -466.87 to 484.64, indicating no significant effect of the second quarter on rice prices. With Season Q3, the coefficient is 154.63 with a standard error of 246.01. The 95% credible interval ranges from -324.23 to 632.00, suggesting no significant effect of the third quarter on rice prices. In Season Q4, the coefficient was -76.16, with a standard error of 248.81. The 95% credible interval ranges from -564.00 to 415.49, indicating no significant effect of the fourth quarter on rice prices.

Regarding Distributional Parameters, the estimate for the standard deviation of the residuals (σ) is 1085.15 with a standard error of 64.44. The 95% credible interval ranges from 968.02 to 1218.19. This indicates substantial unexplained variability in rice prices, suggesting that factors other than the included lagged rice prices and seasonal effects influence current rice prices.

The Convergence Diagnostics are all Rhat values of 1.00, indicating that the Markov Chain Monte Carlo (MCMC) chains have converged well. This means the posterior distributions are reliable. The effective sample sizes (Bulk_ESS and Tail_ESS) are sufficiently large, indicating that the estimates are based on a good number of effective samples, enhancing the results' reliability.

The results suggest a small positive effect of the first lagged of rice prices on current prices, indicating some persistence in rice prices. The significant negative effect of the second lag suggests that higher rice prices two periods ago are associated with lower current prices, possibly due to market corrections or other economic factors. The third lag does not show a significant effect. The seasonal effects do not appear to significantly impact rice prices, as indicated by the wide credible intervals that include zero.

The high variability (σ) indicates that other factors are likely playing a significant role in determining rice prices. To further improve the model, you might consider exploring different lag structures, incorporating additional relevant variables, or applying data transformations to stabilize variance and enhance model performance.

There is a clear presence of rice price volatility, as shown by high residual variability. That is, the standard deviation of residuals is 1085.15 with a narrow credible interval of (968.02 to 1218.19). The high standard deviation implies that rice prices deviate significantly from the predictions the fitted model gives even after accounting for lagged prices and seasonal factors. This high volatility indicates the complexity and instability of the rice market, where many external factors, including possibly unobserved ones, affect the prices.

The model captures some dynamics through the first and second lags of rice prices, but the significant residual volatility suggests that these variables alone are insufficient to explain price behavior. Other factors, including supply shocks, international trade policies, weather conditions, and market speculation, maybe the reasons for the price instability observed. The weak impact of seasonal effects is further indicated by wide credible intervals crossing zero, emphasizing that predictable seasonal patterns are not dominant drivers of price movements in this context.

Another volatility indicator is the shift in the significance of lagged prices. For instance, the strong positive influence of the first lag indicates persistence, while the negative influence of the second lag is seen as a form of market correction. These competing influences indicate price behavior oscillation over time, which characterizes a volatile market. The model results show significant price volatility in rice that is entirely accounted for by lagged prices or seasonal effects. This volatility results from the interaction of external shocks, policy interventions, and structural inefficiencies in the rice market.

The Gelman-Rubin diagnostic results in Table 4 are at 1.0 for the potential scale reduction factor (PSRF), and the upper confidence interval is also at 1.0. These values show that the MCMC chains have converged well since a PSRF close to 1.0 means minimal variation between chains and within-chain variability. There are no values above 1.1, which further confirms the reliability and stability of the posterior estimates obtained from the model. Therefore, the Bayesian analysis can be considered robust and valid for interpreting rice price volatility in this study.

Table 4. Gelman-Rubin Diagnostic Results

Metric	Point Estimate	Upper Confidence Interval
Potential Scale Reduction Factor	1.00	1.00

Figure 3 shows Monte Carlo Markov Chain (MCMC) diagnostics for several model parameters relevant to rice prices and seasonality. The left column displays posterior distributions as histograms, and the right column provides trace plots showing chain mixing over iterations. The intercept term (b_Intercept) is roughly normally distributed around 0, spreading about -400 to 400. Its trace plots show good mixing across all four chains, suggesting proper convergence.

The lagged rice price coefficients are b_lag_rice_price_1 through 3, and their distributions differ. The first lag is primarily positive, with a center of about 0.2; the second and third lags are mainly negative, with centers at around -0.15 and -0.05, respectively. All three lags of trace plots show stable mixing and convergence. The seasonal coefficient b_seasonQ2 is symmetrically distributed near 0, spreading from about -750 up to 750. Its trace plot indicates a good mixing at all the chains, except that it has a much higher variance than the lag coefficients. All parameters have good chain convergence, as reflected in the overlapping traces, which means MCMC sampling performed well.

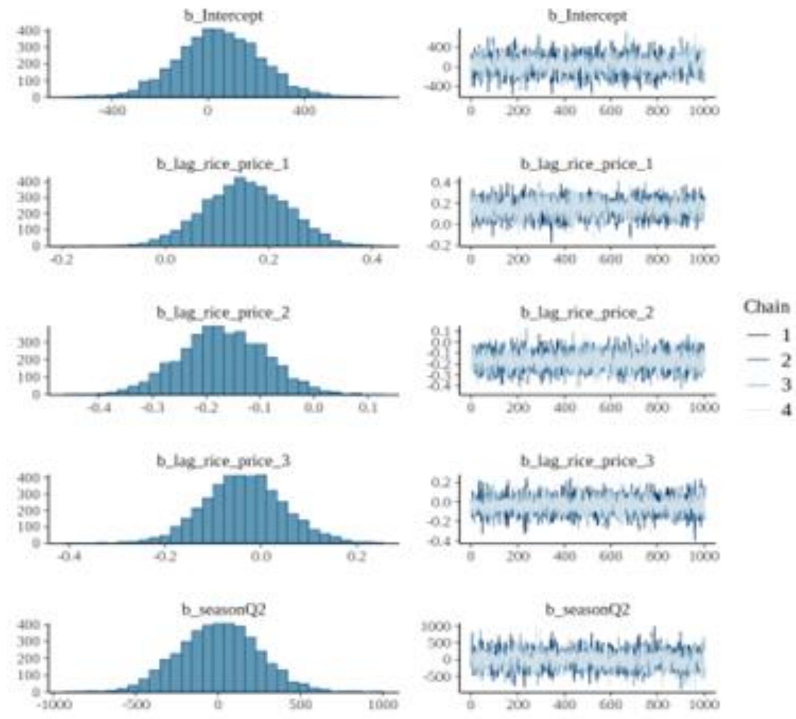

Figure 3. MCMC Rice Prices and Seasonality Diagnostics

Figure 4 compares the probability density of observed data (in dark blue, labeled as "y") and several replicated datasets (in lighter blue, labeled as "y_rep") from what appears to be a predictive check of a statistical model. The distribution is highly asymmetric, with a large peak near zero and a much smaller secondary peak around -2000 on the x-axis. The peak of the distribution is pretty sharp, suggesting that the central tendency is strong in this data set, and these long tails extend both toward positive and negative values and up to about -3000 and 4000, respectively, suggesting extreme values. The replicated datasets (the lighter blue lines) appear to capture the overall shape of the observed distribution well, including both the main and secondary peaks. However, there seems to be variation in how well they capture the exact height of the peaks. This good alignment between the observed and replicated distributions suggests that the model reasonably captures the key features of the data-generating process.

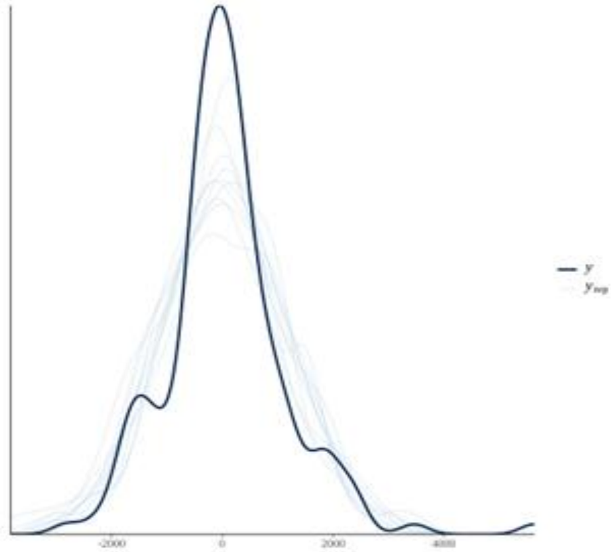

Figure 4. Comparative Probability Density and Replicated Datasets

Figure 5 continues the MCMC diagnostics from the previous image, displaying results for seasonal coefficients Q3 and Q4 and the model's sigma parameter (error term). The seasonal coefficients, b_seasonQ3 and b_seasonQ4, exhibit approximately normal posterior distributions centered around 0, with spreads like Q2 from the previous plot, ranging roughly from -500 to 500 for Q3 and -750 to 750 for Q4. Their trace plots show satisfactory mixing in all four chains, though with considerable variation typical for seasonal impacts. The posterior distribution of the residual standard deviation sigma is located much closer to 1100 with a range close to approximately between 950 and 1250. Also, trace plots for its chain demonstrate stable mixing between all the chains. In contrast, its trace plot does not exhibit dramatic fluctuations, unlike those found in the chains for seasonal coefficients. This proves that this critical parameter, the model's unexplained variation, has stabilized.

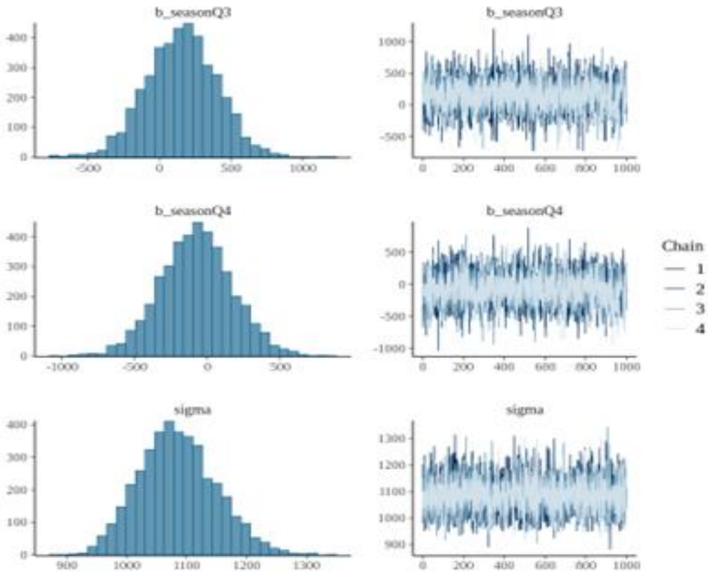

Figure 5. MCMC diagnostics on seasonal coefficients (Q3 and Q4) and Sigma parameter

Figure 6 scatter plot has all the characteristics of being a diagnostic visualization looking at how well parameter estimates explain estimation errors in some statistical models. The x-axis of the plot displays the parameter estimates, between about -2000 and 4000. The y-axis is the estimation error, with roughly 1080 and 1200 values. The cloud of points shows an interesting pattern. A very dense cluster of observations centers around the zero mark on the x-axis, with the points becoming increasingly sparse as we move towards the extremes of the estimate range. Notably, there doesn't seem to be any strong systematic relationship between the magnitude of the estimates and their associated errors, which is usually a desirable characteristic in statistical modeling as it suggests homoscedasticity-constant variance of errors. However, some outlying points, in particular some with high estimation errors around the 1180-1200 range, may be worth investigating to ensure they're not unduly influencing the model's results.

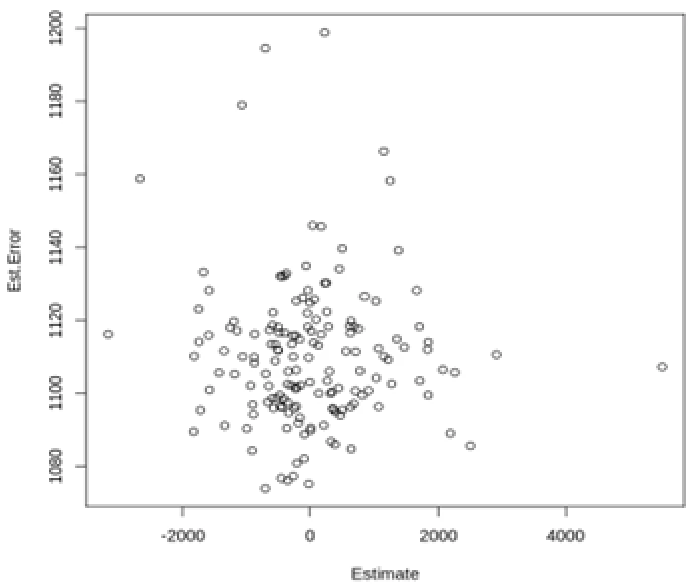

Figure 6. Scatter plot on Parameter Estimates

Table 5 shows the results of the Widely Application Information Criterion (WAIC) and Leave-one-out cross-validation (LOOIC), which agree with each other and give the information criterion as 2703.3 with standard errors of 34.3 and 34.2, respectively. The estimated effective number of parameters is 11.1, with a standard error of 3.4, indicating a simple model. Although 2.5% of the estimates of WAIC exceeded 0.4, which is considered an indicator of instability, the diagnostic Pareto values for LOOIC do not have problematic points, since all (k < 0.7) confirm that the LOO estimates are reliable. This alignment of WAIC with LOOIC, and not having problematic Pareto k-values, favors the adequacy of the model in accounting for the underlying data structure, even though some improvement is required to deal with higher p-WAIC estimates.

Table 5. WAIC and LOOIC results

Metric	WAIC	SE (WAIC)	LOOIC	SE (LOOIC)	Effective Parameters (p)	SE (p)	Notes
elpd	-1351.6	17.1	-1351.7	17.1	11.1	3.4	Comparable in WAIC/LOO
IC (Info)	2703.3	34.3	2703.3	34.2			Lower is better
Pareto k	N/A		All < 0.7	All Good/Estimate-based			

Figure 7 presents a comprehensive set of autocorrelation diagnostics for different aspects of a statistical model, organized in a 4x4 grid of plots. The plots check correlations at various lags (time delays) for different model components, including the main estimates, estimation errors (Es.E), and quantiles (Q2.5 and Q97.5, which represent confidence intervals). Each plot contains bars showing correlations at different lags in the data, with dotted blue lines indicating the ± 0.2 thresholds associated with statistical significance. Indeed, what is particularly telling is that in nearly every plot, the correlation bars stay within these bounds throughout, indicating good model behavior with little concerning autocorrelation. The few deviations where bars slightly exceed this bound seem random rather than systematic, which would be expected by chance. The symmetry of plots corresponding to each other, for instance, "Estm & Es.E" and "Es. E & Estm"-provides cross-validation on the correlation patterns; the y-axis scales for all diagnostics were kept identical from -0.2 to 1.0, thus directly comparable between all of them. Figure 7 suggests that the various components of this model behave independently in time, a generally desirable trait for statistical inference.

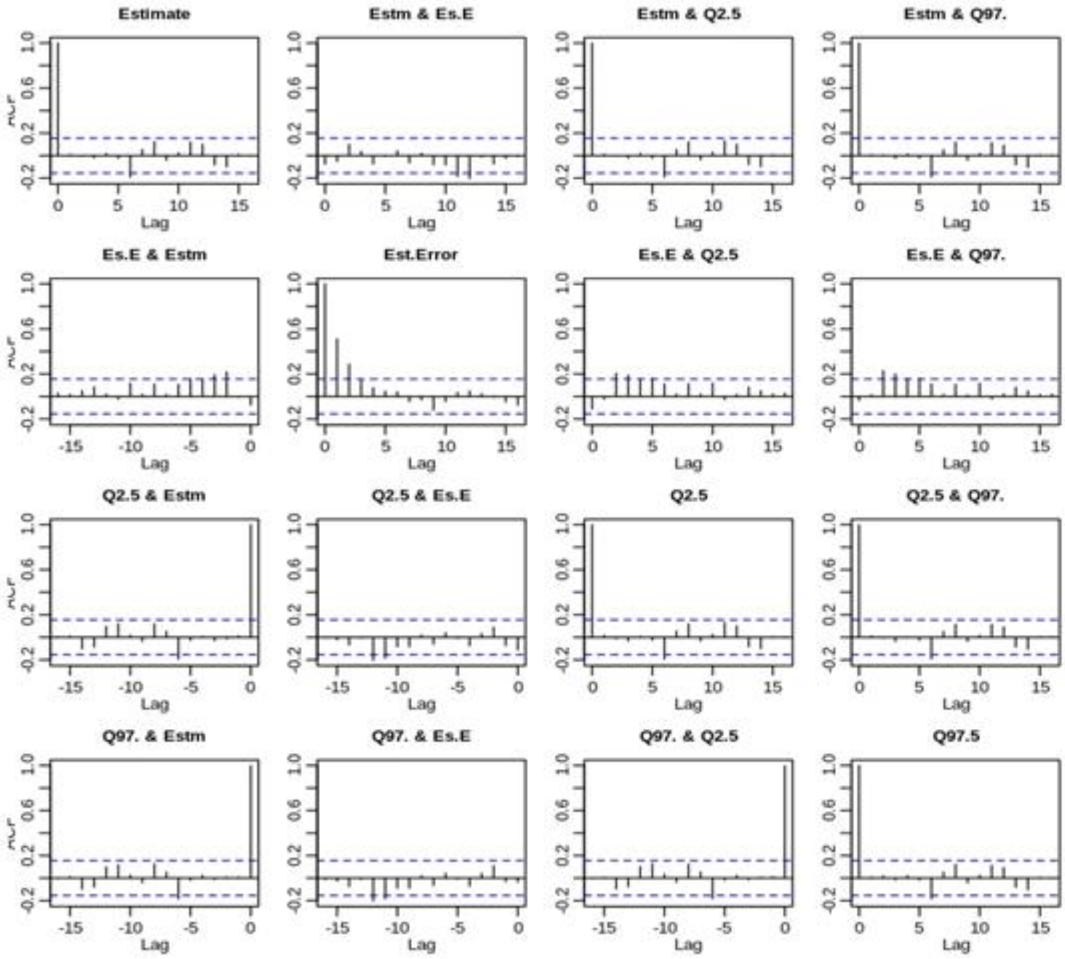

Figure 7. Autocorrelations Diagnostic

Based on the result of this study, these are broad supply and demand economics principles that further carry concepts of market efficiency as well as price volatility, all of which outline, in general terms, why rice prices behave as a given in the Philippine market to be affected by the effect of lagging impacts together with seasonality, then external influences. In its essence, the study implies that prices are not immediately adjusted to the new market conditions, potentially because of structural rigidities, behavioral factors, or government intervention. The persistence of prices is evident in this study, where previous price levels affect current pricing due to contracts, expectations, or inventory adjustments.

The second lag has a significant negative effect, which reflects the principle of market corrections, whereby surges or dips in price from equilibrium eventually get dampened by supply responses or changes in consumer behavior. This aligns with mean reversion, often observed in commodity markets, whereby prices return to a long-term average over time. High variability (σ) in rice prices is associated with price volatility, which proves that markets for staple goods, such as rice, are prone to external shocks. Weather conditions, global trade dynamics, policy changes, and geopolitical events create uncertainties that amplify price fluctuations.

Moreover, the study implicitly leans on the theory of market intervention, which deals with how government policies like tariffs, subsidies, or price controls influence market stability. The insignificant seasonal effects challenge traditional agricultural economics theories, implying that structural inefficiencies or external interventions overshadow natural supply cycles.

The Bayesian Seasonal ARDL model with three lags for rice prices indicates that the volatility of the rice price dynamics in the Philippines provides other valuable insights. These are analyzed using the market failure and government intervention lenses, the pendulum theory of economic policy, and welfare economics and equity.

The Bayesian Seasonal ARDL model highlights the persistence and volatility in rice prices, with significant effects from lagged prices. This persistence suggests that market forces alone are insufficient to stabilize prices, leading to periods of high volatility that harm consumers and farmers. Market failure in this context is evident as the free market fails to provide stable prices, necessitating government intervention. It shows that the highly negative effect of the second lag of rice prices on current prices indicates that previous skyrocketing prices cause market adjustments to correct high prices, but the correction also triggers instability. Government policies on price capping and subsidies can alleviate these fluctuations and thus make the market environment more stable.

The pendulum theory of economic policy is also seen in the Philippines' regulatory approach to rice markets. The pendulum swing is evident from a change in the National Food Authority's (NFA) direct market intervention under liberalization through the Rice Tariffication Law (RTL) and calls to reinstate NFA powers—the results of the ARDL model point to significant lagged effects and seasonal variations for a balanced approach. Though market liberalization under the RTL sought to decrease prices and increase supply, the observed volatility suggests that some form of government control is needed to stabilize the market and protect stakeholders.

On the other side, welfare economics and equity stand on the argument that from the perspective of welfare economics and equity, the ARDL model findings suggest the importance of government interventions for a fair distribution of resources and food security. Seasonal effects that are highly significant could imply higher volatility at times of the year that would have both consumer and producer impacts. Programs like the Rice Competitiveness Enhancement Fund are therefore directed to support farmers in mechanization, seed development, and credit, improving their productivity and resilience to market risks. Interventions like these will ensure stable rice supplies while fairly distributing market gains between consumers and producers.

The results of the Bayesian Seasonal ARDL model on rice price volatility reveal the complex interplay between market forces and government interventions. Market failure calls for government action to stabilize prices and protect stakeholders. The pendulum theory of economic policy is evident in the shifting approaches to market regulation, highlighting the need for a balanced strategy. Welfare economics and equity considerations raise the importance of government policies in ensuring a stable and fair rice market. Understanding these theoretical analysis models will help the government formulate more effective solutions for addressing rice price volatility in the Philippines.

CONCLUSIONS

The Bayesian Seasonal ARDL model for the Philippines, with three lags on rice prices, highlights a persistently volatile nature in rice prices. It shows that past price values and seasonal effects contribute significantly to rice prices, thus highlighting how price volatility can only be partially controlled by the market forces alone; instead, it requires governmental intervention to correct the wrongness of the market. There's that pendulum theory in the shifting approaches of the regulatory mechanism for the market, which directs interventions of the National Food Authority to liberalization under the Rice Tariffication Law, and now, back to calls to restore NFA's powers. The swings in approaches show how there's always a need to find an appropriate balance between freedom and government control over the market to maintain price stability, consumer and farmer fair treatment, and food security in the long term.

Based on these results, the Philippine government is suggested to take a balanced approach that combines strategic market interventions with supportive policies for farmers. Restoring some of the NFA's market intervention powers would help stabilize prices during periods of high volatility. Further strengthening of the Rice Competitiveness Enhancement Fund (RCEF) with more targeted support in farm mechanization, seed development, and credit assistance can enhance farmers' productivity and resilience. Implementing robust monitoring and evaluation mechanisms to assess the impact of these interventions will ensure that policies effectively address the needs of both consumers and farmers, thus contributing to a more stable and equitable rice market.

REFERENCES

1) Antle, J. M. (2015). *Pesticide policy, production risk, and producer welfare: an econometric approach to applied welfare economics*. Routledge.
2) Atienza, R. (2023, October 5). *Economists doubt reported benefits of rice price cap - BusinessWorld Online*. BusinessWorldOnline.https://www.bworldonline.com/top-stories/2023/10/06/550080/economists-doubt-reported-benefits-of-rice-price-cap/#google_vignette
3) Balié, J., Minot, N., & Valera, H. G. A. (2021). Distributional impacts of the rice tariffication policy in the Philippines. *Economic Analysis and Policy*, *69*, 289–306. https://doi.org/10.1016/j.eap.2020.12.005
4) Carretero, J. (2023). NGO to sell P38 per kilo rice | ABS-CBN News. *ABS-CBN*. https://doi.org/1028161032/327e5daf7a15eaefbe56aff6a8c0f521f78eac0f76e6d4ceb49eafb71662c2c7
5) DA-AFID. (2023, September 5). *Rice price ceiling takes effect*. Official Portal of the Department of Agriculture. https://www.da.gov.ph/rice-price-ceiling-on-takes-effect/
6) DA-AFID. (2023, September 25). *Rice Council raises palay buying price - Official Portal of the Department of Agriculture*. Official Portal of the Department of Agriculture. https://www.da.gov.ph/rice-council-raises-palay-buying-price/
7) Dawe, D., & Timmer, C. P. (2012). Why stable food prices are a good thing: Lessons from stabilizing rice prices in Asia. *Global Food Security*, *1*(2), 127-133. https://doi.org/10.1016/j.gfs.2012.09.001
8) Doliente, S. S., & Samsatli, S. (2021). Integrated production of food, energy, fuels and chemicals from rice crops: Multi-objective optimisation for efficient and sustainable value chains. *Journal of Cleaner Production*, *285*, 124900. https://doi.org/10.1016/j.jclepro.2020.124900
9) *FAO.org :* (n.d.). Www.fao.org. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC190932/
10) Flores, M., & Lema, K. (2023, October 4). Philippines' Marcos lifts rice price cap, calls supplies adequate. *Reuters*. https://www.reuters.com/article/markets/currencies/philippines-marcos-lifts-rice-price-cap-calls-supplies-adequate-idUSKBN314049/
11) Gomez, C. J. J. (n.d.). *Navigating Challenges and Opportunities: Current Dynamics in the Philippine Rice Industry – Industry Strategic Science and Technology Plans (ISPs) Platform*. https://ispweb.pcaarrd.dost.gov.ph/navigating-challenges-and-opportunities-current-dynamics-in-the-philippine-rice-industry/
12) Jamille, J. (2024, April 2). *Rice Security in the Philippines: Current Government Measures, Trade Deals, and Inflation Challenges–Industry Strategic Science and Technology Plans (ISPs) Platform*. Dost.gov.ph. https://ispweb.pcaarrd.dost.gov.ph/rice-security-in-the-philippines-current-government-measures-trade-deals-and-inflation-challenges/
13) Jamille, J. (2024, June 20). *Philippine Rice Updates: Increased Farmgate Price, Tariff Cuts, NFA Procurement, Terrace Revival, Rice Root System Enhancement, and Biogas Innovation – Industry Strategic Science and Technology Plans (ISPs) Platform*. Dost.gov.ph. https://ispweb.pcaarrd.dost.gov.ph/philippine-rice-updates-increased-farmgate-price-tariff-cuts-nfa-procurement-terrace-revival-rice-root-system-enhancement-and-biogas-innovation/
14) Jamille, J. (2024, November 15). *Philippine Rice Market Dynamics: Tackling High Retail Prices amid Surging Imports and Production Declines – Industry Strategic Science and Technology Plans (ISPs) Platform*. Dost.gov.ph. https://ispweb.pcaarrd.dost.gov.ph/philippine-rice-market-dynamics-tackling-high-retail-prices-amid-surging-imports-and-production-declines/
15) Kuo, A. D. (2007). The six determinants of gait and the inverted pendulum analogy: A dynamic walking perspective. *Human movement science*, *26*(4), 617-656. https://doi.org/10.1016/j.humov.2007.04.003
16) Kim, D. O. (2011). *Global Financial Crisis and the Future of Labor Unions: Thoughts on the Pendulum Theory* (Doctoral dissertation, Waseda University).
17) LawPhil. (n.d.). *Republic Act No. 11203*. Lawphil.net. https://lawphil.net/statutes/repacts/ra2019/ra_11203_2019.html
18) Link, S. (2018). How might 21st-century de-globalization unfold? Some historical reflections. *New Global Studies*, *12*(3), 343-365. https://doi.org/10.1515/ngs-2018-0024
19) Mangaluz, J. (2023, October 4). *Bongbong Marcos lifts rice price ceiling*. INQUIRER.net. https://business.inquirer.net/424743/bongbong-marcos-lifts-rice-price-ceiling
20) Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors influencing farmers' adoption of modern rice technologies and good management practices in the Philippines. *Agricultural systems*, *110*, 41-53. https://doi.org/10.1016/j.agsy.2012.03.010

21) Mishan, E. (2013). *Economic Efficiency and Social Welfare (Routledge Revivals): Selected Essays on Fundamental Aspects of the Economic Theory of Social Welfare*. Routledge.
22) Murphy, F., Pierru, A., & Smeers, Y. (2019). Measuring the effects of price controls using mixed complementarity models. *European Journal of Operational Research*, *275*(2), 666-676. https://doi.org/10.1016/j.ejor.2018.11.051
23) Naert, F. (2021). Collaborative governance of SDGs: a welfare economics view. In *Handbook of Collaborative Public Management* (pp. 282-298). Edward Elgar Publishing. https://doi.org/10.4337/9781789901917.00031
24) Naylor, R. L., & Falcon, W. P. (2010). Food security in an era of economic volatility. *Population and development review*, *36*(4), 693-723. https://doi.org/10.1111/j.1728-4457.2010.00354.x
25) Nedergaard, P. (2006). Market failures and government failures: A theoretical model of the common agricultural policy. *Public Choice*, *127*(3), 385-405. https://doi.org/10.1007/s11127-005-9000-1
26) News, A.-C. (2023). Marcos Jr.: Price cap stabilized rice prices | ABS-CBN News. *ABS-CBN*. https://doi.org/1028051012/c4a9b9591e0cccfd5eb435743e9f61de93dd66f409192acbb057f921ce36f0c5
27) Office, D. P. (2024, December 9). *New law extends RCEF until 2031, triples budget to boost rice industry modernization - Official Portal of the Department of Agriculture*. Official Portal of the Department of Agriculture. https://www.da.gov.ph/new-law-extends-rcef-until-2031-triples-budget-to-boost-rice-industry-modernization/
28) Office, D. P. (2024, December 12). *DA Secretary seeks NFA powers to stabilize rice prices - Official Portal of the Department of Agriculture*. Official Portal of the Department of Agriculture. https://www.da.gov.ph/da-secretary-seeks-nfa-powers-to-stabilize-rice-prices/
29) Office, P. (2012, February). *Subsidizing the National Food Authority: Is It a Good Policy?* Working Papers; eSocialSciences. https://ideas.repec.org/p/ess/wpaper/id4814.html
30) *OPINION: Rice Tariffication, Good Governance, and Real Food Security*. (2019). Pids.gov.ph. https://www.pids.gov.ph/details/opinion-rice-tariffication-good-governance-and-real-food-security
31) Panti. L. (2024). *NEDA: Reduced rice tariffs failed to lower prices*. GMA News Online. https://www.gmanetwork.com/news/money/economy/929579/neda-reduced-rice-tariffs-failed-to-lower-prices/story/
32) *Philippines Sep rice inflation hits 14-year high despite price control measures*. (2023). S&P Global Commodity Insights. https://www.spglobal.com/commodity-insights/en/news-research/latest-news/agriculture/100523-philippines-sep-rice-inflation-hits-14-year-high-despite-price-control-measures
33) Poulton, C., Kydd, J., & Dorward, A. (2006). Overcoming market constraints on pro-poor agricultural growth in Sub-Saharan Africa. *Development policy review*, *24*(3), 243-277. https://doi.org/10.1111/j.1467-7679.2006.00324.x
34) *PRRD signs into law Sagip Saka Act | Philippine News Agency*. (2019). Pna.gov.ph. https://www.pna.gov.ph/articles/1070765
35) Ramos, J. A. (2023, September 4). *Gov't will help retailers affected by rice price cap – Romualdez*. INQUIRER.net. https://newsinfo.inquirer.net/1826076/govt-will-help-retailers-affected-by-rice-price-cap-romualdez
36) Rapisura, M. (2023, September 11). *The Rice Price Cap in the Philippines: Pros, Cons, and Long-Term Implications*. Social Enterprise Development Partnerships, Inc. https://sedpi.com/en/the-rice-price-cap-in-the-philippines-pros-cons-and-long-term-implications/
37) Reuters Staff. (2024, July 8). Philippines wants to boost rice cooperation with Vietnam to ensure food security. *Reuters*. https://www.reuters.com/world/asia-pacific/philippines-wants-boost-rice-cooperation-with-vietnam-ensure-food-security-2024-07-08/
38) *Rice – Industry Strategic Science and Technology Plans (ISPs) Platform*. (n.d.). PCAARRD's Industry Strategic Science and Technology Programs. https://ispweb.pcaarrd.dost.gov.ph/isp-commodities/rice/
39) Rivera, D. (2023, September 2). *"Rice price cap to affect farmers, consumers."* Www.pids.gov.ph. https://www.pids.gov.ph/details/news/in-the-news/rice-price-cap-to-affect-farmers-consumers
40) Rivera, D. (n.d.). *"Rice price cap to affect farmers, consumers."* Philstar.com. https://www.philstar.com/headlines/2023/09/02/2293214/rice-price-cap-affect-farmers-consumers
41) Rocha, C. (2007). Food insecurity as market failure: a contribution from economics. *Journal of Hunger & Environmental Nutrition*, *1*(4), 5-22. https://doi.org/10.1300/J477v01n04_02
42) Roy. (2019, June 19). *Sagip Saka Law: A better future for the farmers and fisherfolk*. Institute for Small-Scale Industries. https://beta.entrepreneurship.org.ph/2019/06/19/sagip-saka-law-a-better-future-for-the-farmers-and-fisherfolk/

43) Salakpi, E. E., Hurley, P. D., Muthoka, J. M., Barrett, A. B., Bowell, A., Oliver, S., & Rowhani, P. (2022). Forecasting vegetation condition with a Bayesian auto-regressive distributed lags (BARDL) model. *Natural Hazards and Earth System Sciences*, *22*(8), 2703-2723. https://doi.org/10.5194/nhess-22-2703-2022
44) Santos, J. M. L. (2000). Problems and potential in valuing multiple outputs: Externality and public-good non-commodity outputs from agriculture. *Valuing Rural Amenities*, *215*.
45) *September inflation rises to 6.1%, rice prices blamed*. (2019). Pids.gov.ph. https://www.pids.gov.ph/details/news/in-the-news/september-inflation-rises-to-6-1-rice-prices-blamed
46) Stiglitz, J. E. (2010). Government failure vs. market failure: Principles of regulation. *Government and markets: toward a new theory of regulation*, 13-51.
47) *Summary Inflation Report Consumer Price Index (2018=100): October 2023 | Philippine Statistics Authority | Republic of the Philippines*. (n.d.). Psa.gov.ph. https://psa.gov.ph/content/summary-inflation-report-consumer-price-index-2018100-october-2023
48) Sun, A., Işık, C., Razi, U., Xu, H., Yan, J., & Gu, X. (2024). Unravelling complexities: a study on geopolitical dynamics, economic complexity, R&D impact on green innovation in China. *Stochastic Environmental Research and Risk Assessment*, 1-16. https://doi.org/10.1007/s00477-024-02804-1
49) Tobias, A. (2019, May 23). *The Philippine Rice Tariffication Law: Implications and Issues*. FFTC Agricultural Policy Platform (FFTC-AP). https://ap.fftc.org.tw/article/1372
50) Ullah, A., Arshad, M., Kächele, H., Khan, A., Mahmood, N., & Müller, K. (2020). Information asymmetry, input markets, adoption of innovations and agricultural land use in Khyber Pakhtunkhwa, Pakistan. *Land use policy*, *90*, 104261. https://doi.org/10.1016/j.landusepol.2019.104261
51) *What is the KADIWA Program by Department of Agriculture*? (2024, May 14). Assistance.PH. https://assistance.ph/kadiwa-program/
52) Winston, C. (2007). *Government failure versus market failure: Microeconomics policy research and government performance*. Brookings Institution Press.
53) Zhang, Z., Li, F., Liang, W., Huang, L., Jiang, S., & Duan, Y. (2023). Economic performance and natural resources commodity prices volatility under COVID-19 perspective: Moderating role of economic freedom. *Resources Policy*, *86*, 104149. https://doi.org/10.1016/j.resourpol.2023.104149

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