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VECTOR AUTOREGRESSIVE (VAR) MODELING OF SWINE PRODUCTION USING POULTRY PRODUCTION AND ECONOMIC FACTORS IN THE PHILIPPINES

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ABSTRACT

A multivariate time series modeling of five endogenous variables was explored in this study. Using vector autoregressive (VAR) modeling, causal structures of the data under investigation are imposed and the resulting causal impacts of unexpected shocks or innovations to specified variables on the variables in the model are summarized.

Results of the analysis revealed that past values, particularly, lag 1 to 4, of swine production, chicken production, import swine, import chicken and inflation rate can be used to obtain a model that would provide forecast for the series. Forecast efficiency tests were performed based on RMSE, MAD and MAPE. Moreover, Variance Decomposition revealed that swine is the primary contributor in forecasting itself followed by chicken production and import swine in the long run.

Keywords: Vector Autoregressive (VAR) Modelling, Forecast Error Variance Decomposition

INTRODUCTION

In Asian countries particularly Cambodia, Laos, the Philippines, and Vietnam, animal production has been increasing rapidly. The Philippines, located in Southeast Asia, is an archipelago with a total area of 300,000 Km^2 wherein 32% is devoted to agriculture.

Livestock and poultry production is a very important and rapidly expanding component of the Philippine agricultural economy. In the Philippines, the swine industry is the second largest contributor to the country's agriculture coming in second to rice. The top producing regions include CALABARZON (13.13%), Western Visayas (11.56%), Central Luzon (10.66%), Bicol Region (7.84%) and Eastern Visayas (7.30%).

Moreover, the swine industry performance report by the Philippine Statistics Authority (PSA) as of July 1, 2015, indicated that the country's total swine inventory stood at 12.27 million heads. This was 2.40 percent higher than the previous year's inventory of 11.98 million heads.

The importation of low-priced beef, buffalo meat, and poultry meat may create a shift in consumption from pork to these cheaper alternatives. The establishment of large-scale integrated pig farms by foreign investors in the free port zone using imported breeder stocks, technology, and other production inputs is an indirect importation of pork with minimal or no tariff at all. This scenario poses a threat to the local swine entrepreneurs. Hence, the local swine industry needs to modernize to ensure that it can withstand any form of competition. To enhance its global competitiveness, the government should work with the private sector in providing the livestock sector with policy reforms on importation, trade, pricing of inputs and support regarding technology and infrastructure.

The vector autoregression (VAR) model is one of the most successful, flexible, and easy to use models for the analysis of such dynamic multivariate time series. Thus, this study was conducted to obtain a model for swine production using poultry production and economic factors such as import and the inflation rate of the Philippines using the quarterly series data from the Philippine Statistics Authority (PSA) and Bureau of Animal Industry (BAI). It aimed to present the effects of these factors by applying the VAR modeling technique in forecasting and explaining the structural relationship through Variance Decomposition.

Significance of the Study

Livestock production and changes in import, export and inflation rate influence one another. The notion of this cause and effect system must be handled carefully, and it is necessary to analyze the system as a whole. A statistical analysis suitable in forecasting and analyzing these effect is Vector Autoregressive (VAR) modeling, for the government's agricultural sector, results of the study will give insights on what projects must be performed to address the problems brought by importation on the swine and poultry industry. Also, the results may serve as a basis for improving the production of this livestock to lessen the importation and possibly open the gate for the exportation of swine in the future.

METHODOLOGY

Data Source

The quarterly data of the swine and poultry production in the Philippines from January 1997 to December 2015 were obtained from the Philippine Statistics Authority (PSA). Import data was obtained from the National Veterinary Quarantine Service of the Bureau of Animal Industry (BAI-NVQS) and the inflation rate data from http://www.gdpinflation.com/2013/10/inflation-rate-in-philippines-from-1994.html. In determining the forecast efficiency, 2014 and 2015 quarterly data served as the holdout sample.

Methods of Analysis

In describing the basic features of the data, descriptive statistics were obtained specifically, the mean, minimum, maximum, and standard deviation per quarter of swine production series.

In explaining the pattern or behavior of the time series, the graphical method was used. Augmented Dickey-Fuller test was used to formally test the stationarity of the series, testing the null hypothesis that the series is non-stationary.

In selecting the VAR lag length, Likelihood Ratio Test (LR), Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC) and Hanna-Quinn Information Criterion (HQ) were obtained. The lowest value for each criterion was selected as the optimal lag length for the VAR Model.

Three measures of efficiency of the model were used to evaluate the precision of forecasting systems. Each one of them was based on the error or deviation between the forecasted and actual values: Root Mean Squared Error (RMSE), Mean Absolute Deviation (MAD) and Mean Absolute Percentage Error (MAPE). The lower the error measure, the higher the forecasting ability.

Variance Decomposition was used to indicate the amount of information each variable contributes to the other variables in VAR. This aids the interpretation of the VAR model. Thus, variance decomposition determined the amount of forecast error variance of each of the variables that can be explained by shocks as compared to other variables.

Analyses performed were subjected at 5% level of significance. All computations were done using EViews 8 and MS Excel 2013.

RESULTS AND DISCUSSIONS

Description of the Data

Table 1 shows the quarterly descriptive statistics of swine production from 1997 to 2013. Swine production ranges from 317.65 to 581.39 thousand metric tons having the highest average of 496.30 thousand metric tons in the fourth quarter.

Figure 1 shows that the swine production in the Philippines is not constant over time. An increasing trend from 1997 to 2013 was depicted by the time series plot. Lowest point per year was found in the third quarter and highest during the fourth quarter. This may be due to increasing production on swine during the holiday season which falls in the fourth quarter.

Stationary and Seasonality

The time series plots of the swine production showed that there is a presence of seasonality which occurs every fourth quarter. Thus, the series was deseasonalized and was subjected for the analysis.

For testing of stationarity, Augmented Dickey-Fuller Test (ADF) was used, and the test revealed that the original series failed to reject the null hypothesis that it is non-stationary (has a unit root).

Figure 2 shows the deseasonalized series of swine production and the series showed that there are no existing patterns left in the series.

VAR Modeling Process

Lag Length Selection

Table 3 revealed the result of the different lag length criteria where FPE and AIC gave a length of Lag 4, Lag 3 based on LR Test and Lag 2 based on SC and HQ. Since two of the tests provided a lag length of 4, this was used for the analysis. Also, it was observable from the time series plots that the series cuts at lag 4.

Normality and Heteroskedasticity Tests

Table 4 shows the VAR residuals normality and heteroskedasticity test using the Jarque-Bera (J-B) Test and Chi-square, respectively. Jarque-Bera tests the null hypothesis that the residuals follow a normal distribution. Probability value equal to 0.0001 indicates that the residuals are multivariate non-normal. Moreover, the Chi-square test revealed that variances are constant since the test failed to reject the null hypothesis of homoscedasticity, having a probability value of 0.7270.

Overall, VAR (4) meets the assumption of homoscedasticity of variance, stability condition and parsimonious model. The VAR (4) model yields the following equation of D4Swine (Y_t) as dependent variable while its corresponding lag 1 to lag 4 as the independent variables.

$$\widehat{Y_t} = 4.2576 + 0.7341Y_{t-1} + 0.0245X_{t-1} - 0.2156Z_{t-1} - 0.1636V_{t-1} + 2.106W_{t-1} - 0.101Y_{t-2} + 0.1660X_{t-2} + 0.113Z_{t-2} + 0.1083V_{t-2} - 1.9098W_{t-2} + 0.0209Y_{t-3} - 0.1948X_{t-3} - 0.1473Z_{t-3} - 0.0447V_{t-3} - 0.3593W_{t-3} - 0.1083Y_{t-4} + 0.1252X_{t-4} - 0.0337Z_{t-4} + 0.2077V_{t-4} + 1.2815W_{t-4}$$

Forecasting

Swine

Figure 3 shows the plot of actual, predicted and forecasted series of quarterly swine production in the Philippines. It can be observed that forecasted values follow the behavior of the actual series which is an indicative of low values of measures of efficiency as shown in Table 5.

Structural Analysis

Variance Decomposition

The study considered the short-run and long-run relationships between the variables. For swine production, aside from swine itself, the influence of chicken production contributed most in forecasting swine having 5.70% during the 4th quarter. For the long-run relationship, up to the 20th quarter, still chicken contributed most in forecasting swine having 10.07%.

Table 1: Descriptive Statistics of Swine Production of the Philippines from 1997 to 2013

Variable	Quarters	Mean	Minimum	Maximum	Std. Dev.
Swine Production (thousand metric tons)	Q1	418.10	327.41	475.75	49.52
	Q2	412.11	323.72	480.50	49.24
	Q3	408.46	317.65	474.53	49.15
	Q4	496.30	389.00	581.39	57.87

Quarterly Time Series Data

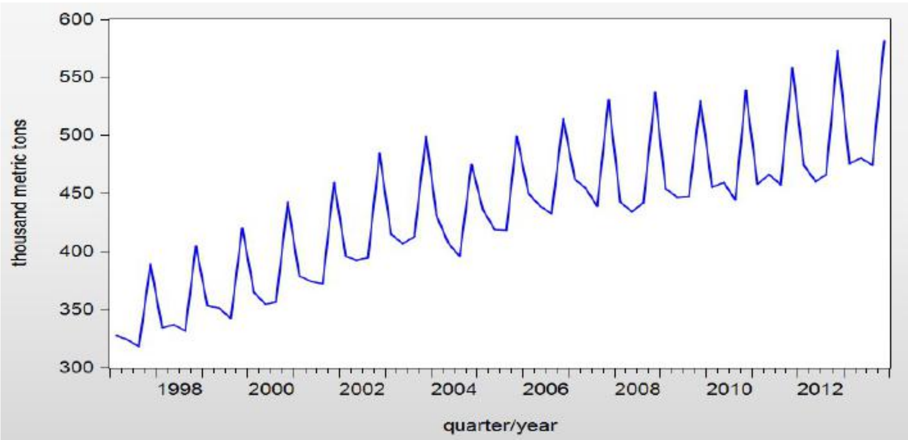

Figure 1: Time Series Data on Swine Production from 1997 to 2013

Table 2: Test for the Stationarity of the Series using ADF

Variable	ADF Test Stat	p-value	Conclusion
Original Series			
Swine	2.6249	0.9976	Non-Stationary Series
Deseasonalized Series			
D4Swine	-2.9354	0.0039	Stationary Series

*Null Hypothesis: It has a unit root

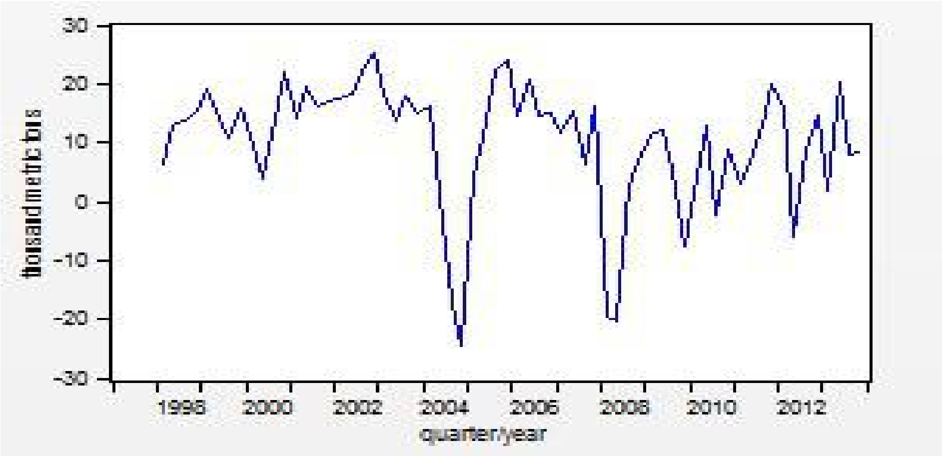

Figure 2: Deseasonalized Swine Production Series

Table 3: VAR Lag Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1001.1940	NA	253000000	33.5398	33.7143	33.6081
1	-932.5576	123.5453	59365435	32.0853	33.1324*	32.4949*
2	-900.9262	51.6648	48437476	31.8642	33.7840	32.6152
3	-873.9481	39.5678*	47438183	31.7983	34.5907	32.8906
4	-845.1855	37.3914	45713479*	31.6729*	35.3379	33.1065

* indicates lag order selected by the criterion

Table 4: VAR Residual Normality and Heteroskedasticity Test

	Test	Test Stat	Prob.
Normality	Jarque-Bera Test	34.7378	0.0001
Heteroskedasticity	Chi-square test	578.6747	0.7270

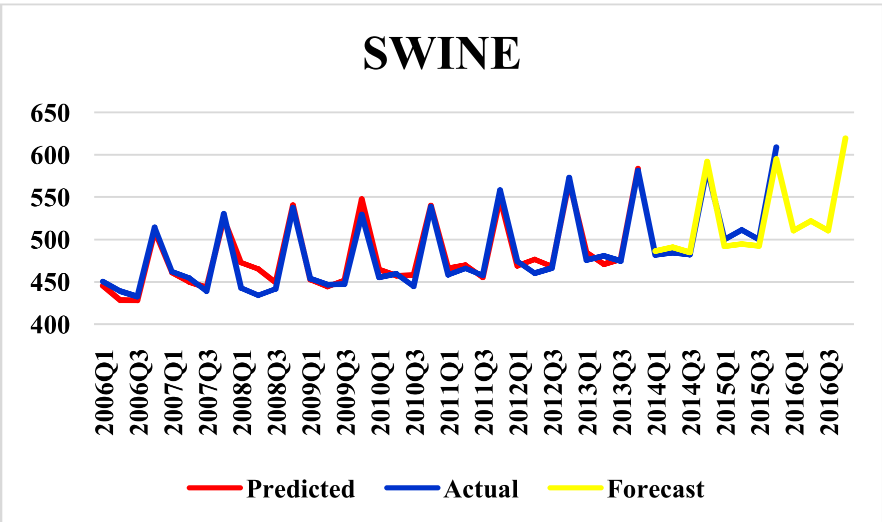

Figure 3: Actual and Forecasted Values of Quarterly Swine Production

Table 5: Results for the Measures of Efficiency of the Models

	RMSE	MAPE	MAD
Swine Production	9.4998	1.6018	8.4446

Table 6: Variance Decomposition of D4Swine

Period	S.E.	D4SWINE	D4CHICKEN	D4IMPORT_SWINE	D4IMPORT_CHICKEN	D4INFLATION_RATE
1	9.664122	100.0000	0.000000	0.000000	0.000000	0.000000
2	11.50678	93.98858	0.274458	1.722746	0.497467	3.516748
3	12.33744	86.87262	5.829452	2.017606	0.554941	4.725377
4	12.47601	85.49333	5.700693	3.403131	0.765658	4.637191
5	12.62447	84.78765	5.770106	3.904617	0.883765	4.653860
6	12.87208	81.57463	9.258862	3.757905	0.864620	4.543979
7	12.98623	80.14692	10.05130	3.718702	1.601950	4.481126
8	13.08912	79.08455	9.906506	4.467416	2.003119	4.538407
9	13.12515	78.65112	9.852269	4.852592	2.122639	4.521377
10	13.15344	78.41408	9.816329	4.952264	2.204120	4.613208
11	13.18225	78.31830	9.774354	5.064144	2.195477	4.647720
12	13.21858	78.06497	9.962362	5.040998	2.217816	4.713854
13	13.23719	77.94403	10.04275	5.042156	2.233081	4.737989
14	13.24076	77.92207	10.04346	5.048045	2.249400	4.737031
15	13.25051	77.81552	10.07960	5.079967	2.249741	4.775171
16	13.25966	77.74902	10.06569	5.082228	2.251913	4.851148
17	13.27551	77.69932	10.08563	5.073192	2.249406	4.892455
18	13.28543	77.71742	10.07437	5.066850	2.246396	4.894967
19	13.28716	77.71629	10.07298	5.067440	2.245837	4.897453
20	13.28925	77.69338	10.06991	5.072500	2.245293	4.918920

SUMMARY, CONCLUSION, AND RECOMMENDATION

This study using the quarterly time series data of swine, chicken, import swine, import chicken, and inflation rate investigated the behavior of each time series. Multivariate Time Series Modeling specifically VAR Modeling was performed, and VAR (4) model was selected.

Results of forecast efficiency tests revealed that swine has low value of forecast error corresponding to greater forecasting ability.

Variance Decomposition revealed that swine is the primary contributor in forecasting itself followed by chicken production and import swine in the long run.

Overall, VAR revealed that past values, mainly lag 1 to lag 4, of swine, chicken, import swine, import chicken and inflation rate can be used to obtain a model that would provide a forecast for swine production series.

There are a vast amount of multivariate time series analyses available, and Vector Autoregressive modeling is just one of it. Thus, it is recommended for future researchers to consider other analysis such as Structural Vector Autoregressive (SVAR) because SVAR Models, being the combination of Structural Equation

Modeling (SEM) and Vector Autoregressive (VAR) Models, would be helpful in incorporating the dynamic structures of the economic variables.

Other variables such as Commodity Prices, particularly the prices of swine and chicken be included in the analysis to determine its relationship to swine production. Also, an updated dataset is suggested.

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