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ANALYSIS OF SEASONALITY IN MONTHLY PORK PRICES IN THE PHILIPPINES BASED ON X-12 ARIMA

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ABSTRACT

Seasonal movements in prices are assumed to be predictable as they are expected to recur within one year periods. The study aimed to capture seasonality in monthly prices of pork in the Philippines in order to reveal underlying cyclical and trend movements in the economy. Secondary data on nominal monthly price series of pork at the national level covering the period 1990–2016 used were obtained from the Philippine Statistical Authority (PSA) CountryStat website. The X-12 ARIMA (autoregressive integrated moving average) method was used to seasonally adjust the monthly farm gate and retail prices of pork in the Philippines. Results show that both price series exhibited clear upward trends and normal irregular variations. F-tests for the presence of seasonality also revealed that monthly farm gate and retail prices of pork present stable seasonality along with moving seasonality at 1% level of probability. Trading day and leap year effects were found to be insignificant.

Key words: X-12 ARIMA, trend-cycle, seasonality, irregular component

INTRODUCTION

Swine production in the Philippines is a P191 billion industry (DOST-PCAARRD 2016). Next to rice, the swine industry contributes 18.25 percent to the country's gross value added (PSA 2017). The Philippines is one of the top ten countries in the world with the fastest growing meat consumption. According to the Organization for Economic Cooperation and Development (OECD), 2017, an average Filipino consumes about 14.2 kg of pork (2 kg more than the world's average pork consumption), 11.6 kg of chicken and 3.0 kg of beef or veal. The country's present total meat consumption of 28.8 kg per year is projected to further grow given the increasing population and rising income. In 2025, the pork consumption per capita in the Philippines is projected to increase to about 14.35 kilograms per person annually (Statista).

Because of the importance of meat in the diet composition (Ompoy and Prantilla 2013) of Filipinos, especially for low-income households, understanding the behavior of meat prices, both the overall long-term trend of prices and the intra-year price fluctuations, is a major concern for the Philippine Government. Gordoncillo et al. (2016) claim that any movement in meat prices can have a significant and serious impact on household food security and well-being. The producers, consumers, policymakers, and other stakeholders directly or indirectly involved in production, consumption, and marketing of hogs, need to take into account these price variations in their decision-making process.

Agricultural prices often follow a seasonal pattern because production is seasonal and storage is costly. In some cases, seasonal demand (such as holiday consumption) may also contribute to seasonality in agricultural prices. The literature abound in long-term projections about the supply and

demand for hogs, trade and prices but the systematic analysis of seasonality in livestock prices has received less attention. This paper hopes to address the research gap by analyzing seasonality in the monthly prices of pork in the Philippines.

Seasonality in prices reflects monthly or quarterly variations caused by changes in the weather, agricultural arrangements, social traditions, among others (Zhou and Dong 2007). Seasonal movements are assumed to be predictable as they are expected to recur within one year periods, and enable making short term forecast. Understanding seasonality is essential for correct seasonal adjustment and analysis of the data, and useful for making better forecast in production and marketing decisions, and food security interventions.

The main goal of this study was to analyze the seasonality of monthly farm gate and retail prices of pork. To achieve this goal, X-12 ARIMA was used to seasonally adjust the monthly price series of pork from 1990–2016. Seasonal adjustment is a tool for highlighting the underlying trends and short-run movements of economic processes, as well as unexpected events and shocks of economic processes. Hence, seasonally adjusted data can facilitate control of various aspects of government policy. The comparison based on adjusted data is more reliable because the seasonally adjusted time series are artificial data that depict the economy unaffected by repetitive events like usual weather conditions, holidays, typical social habits and practices. They are especially helpful when comparing the periods in the presence of outliers.

METHODOLOGY

Secondary data on monthly nominal farmgate and retail prices of pork in the Philippines from 1990 to 2016 were gathered from CountryStat of the Philippine Statistics Authority (PSA) website (http://countrystat.psa.gov.ph). The X-12 ARIMA model was used in the analysis. This model has been widely used by most leading statistical institutes world-wide to seasonally adjust data. It is comprehensive, with many options available for tailoring seasonal adjustment to each individual series, and it also provides procedures for examining trading day, holiday and some calendar effects of the time series.

X-12 ARIMA

The US Census Bureau developed in 1998 the X-12 ARIMA model, which is an extended and improved version of the X-11 and X-11ARIMA/88 method of Statistics Canada (Dagum 1980, Hungarian Central Statistical Office 2007, Zhou and Dong 2012), and provided new capabilities and methods of seasonal adjustment program (Findley et al. 1998).

X-12 ARIMA consists of two linked parts: the regARIMA model for estimation of the deterministic components (mainly calendar effects), and the decomposition part of the linearized series for the stochastic components (trend-cycle, seasonality, and irregulars) performed using the X-11 filters combined with those of the ARIMA model extrapolations. According to the *Guide to Seasonal adjustment with X-12 ARIMA* (ONS 2007), in practice most economic time series exhibit a multiplicative relationship and hence the multiplicative decomposition usually provides the best fit. However, because negative values were observed in the monthly farm gate and retail prices of pork, the additive seasonal decomposition was more appropriate. The ARIMA process for both monthly price series was $(0, 1, 1) \times (0, 1, 1)_{12}$. The default 13-term moving average Henderson filter was used. Diagnostic methods include residual diagnostics and F-test for seasonality.

Fig.1 presents the flow diagram for seasonal adjustment with X-12 ARIMA. As described by Findley et al. (1998), the program runs several steps. First, the series is modified by any user-defined prior adjustments. Then the program fits a regARIMA model to the series in order to detect and adjust

for outliers and other distorting effects for improving forecasts and seasonal adjustment. The program then uses a series of moving averages to decompose a time series into three components. In the last step a wider range of diagnostic statistics are produced, describing the final seasonal adjustment, and giving pointers for possible improvements which could be made.

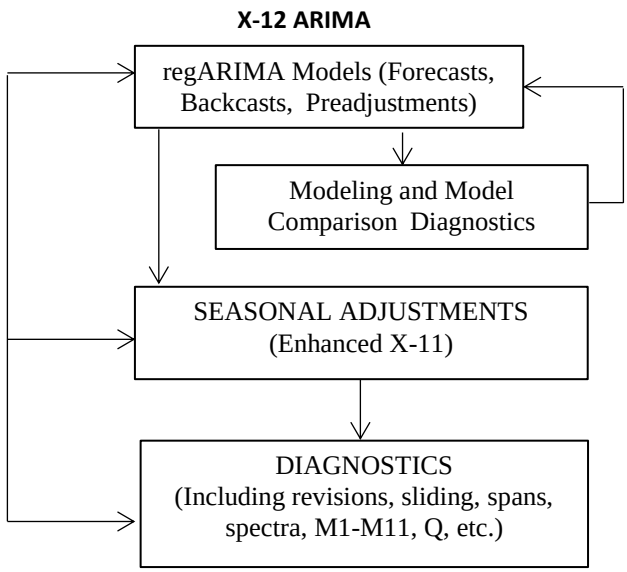

Fig. 1. Flow diagram for seasonal adjustment using X-12 ARIMA (Source: Findley et al. 1988)

RESULTS AND DISCUSSION

The Original Price Series

Before doing seasonal adjustment, the original series were checked for stationarity, additive outliers (AOs), and the level shifts (LSs). The ARIMA model requires the data series to be stationary. A time series is stationary if its mean, variance and autocorrelation structure do not change over time. If the series is not stationary, backcast or forecast of the series, AOs or LSs detection cannot be made available, i.e., the regARIMA part of the X-12 ARIMA would feedback false results (Zhou and Dong 2012). Outliers are observations which do not fit in the tendency of the time series observed as they differ dramatically from the typical pattern of the trend and/or seasonal components (Eurostat, n.d.). Their presence can substantially distort the estimation of the time series component and can affect the moving averages applied in X-12 ARIMA resulting in unrepresentative pattern of the price series.

The behavior of the pre-adjusted (original data series) monthly nominal farmgate and retail prices of pork is shown in Fig. 2. Both price series exhibited a seemingly upward trend with irregular short-term fluctuations. One can infer from the figure that both price series were not stationary.

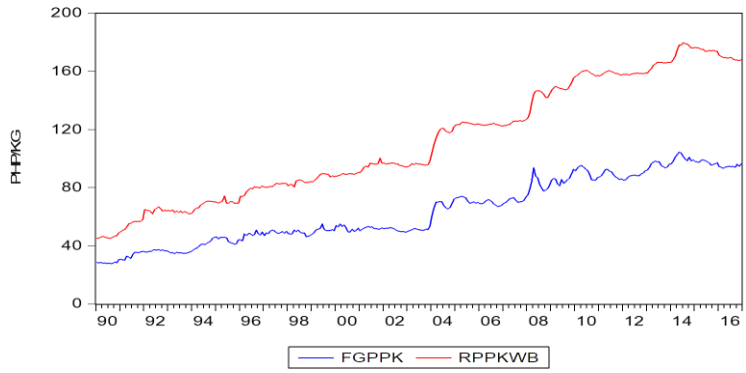

Fig. 2. Monthly farmgate and retail prices of pork in the Philippines, 1990-2016.

In order to achieve stationarity, the original farmgate and retail price series were transformed by differencing (*D*) the data, i.e., $y_t = x_t - x_{t-1}$. The first and second seasonal differences of the original farm gate and retail prices of pork are shown in Figs. 3a and 3b, respectively. A cursory examination of the plots indicates that the first difference already improved the stationarity of both price series such that the second seasonal difference resulted in over-differenced series.

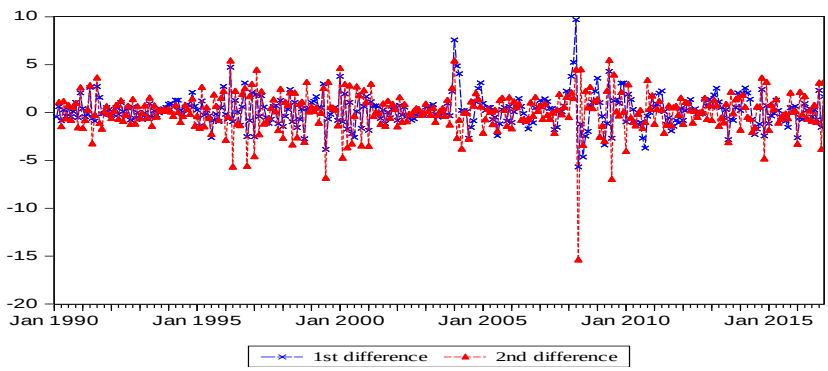

Fig. 3a. 1st seasonal difference $\Delta_{12}mY_t$ and 2nd seasonal difference $\Delta^2_{12}mY_t$ for the monthly farm gate price of pork.

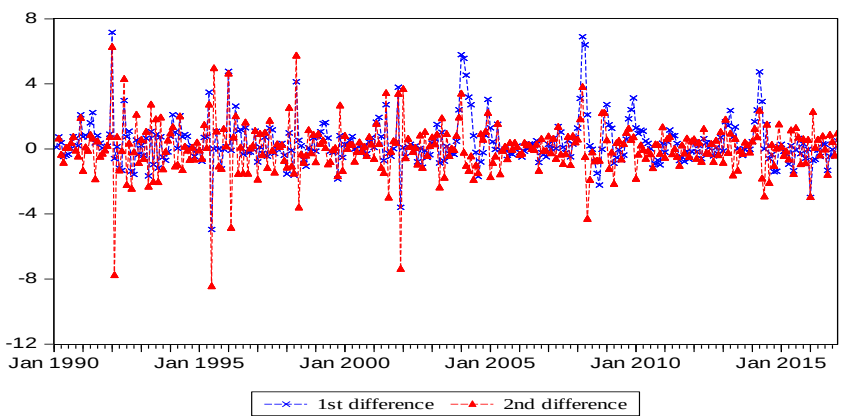

Fig. 3b. 1st seasonal difference $\Delta_{12}mY_t$ and 2nd seasonal difference $\Delta^2_{12}mY_t$ for the monthly retail price of pork

To check for autocorrelation, X-12 ARIMA can produce Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the residuals, along with (Ljung and Box 1978) summary Q-statistics. The ACF and PACF are graphed in Figs. 4a and 4b for farmgate price and retail price, respectively. The ACF of the 1st differenced monthly farmgate and retail price series resembles (0, d, 1) case non-seasonality and (0, d, 1) case seasonality.

The correlogram suggests that (p,d,q) *x* (P, D, Q)$_s$ equals (0, 1, 1) *x* (0, 1, 1) where *d* is order non-seasonal difference, D is order seasonal difference, p and q is the order of non-seasonal autocorrelation process of the explained variable and the non-seasonal white noise's moving average process, respectively; P and Q is the seasonal autocorrelation process of the explained variable and the seasonal white noise's moving average process, respectively. The orders are supported by Akaike Information Criterion test.

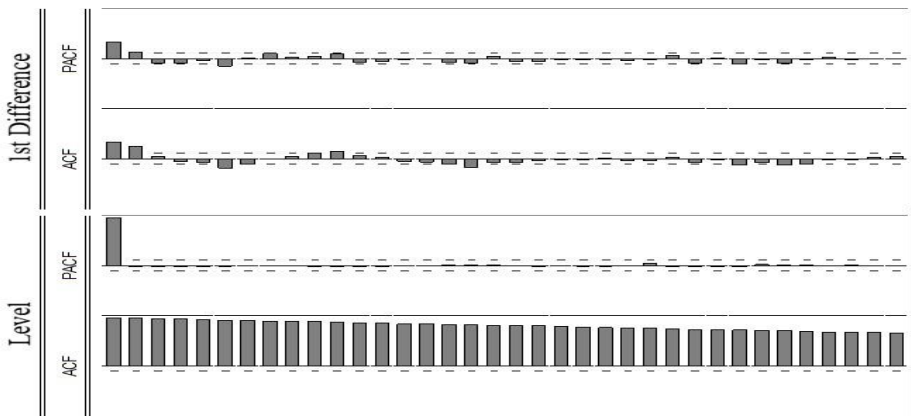

Fig. 4a. The correlogram of the monthly farm gate price of pork.

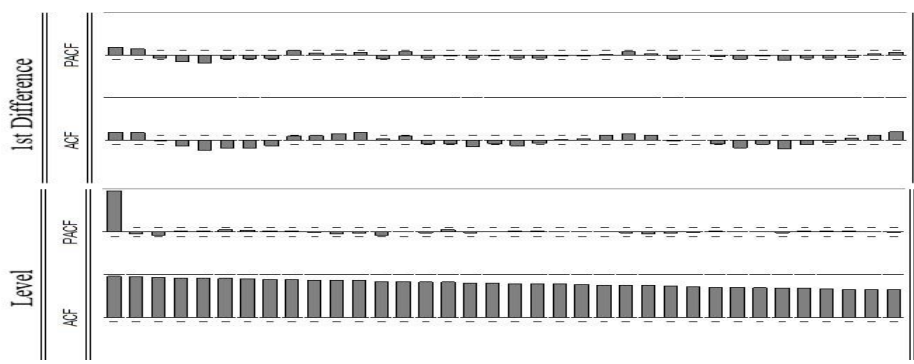

Fig. 4b. The correlogram of the monthly retail price of pork

The regARIMA adjusts outliers, trading day effects, holiday effects and user-specified effects using seasonal ARIMA model before the X-11 seasonal adjustments. In this study, the AO/LS outliers were tested at 1% level of probability for both farmgate and retail prices of pork. For monthly farmgate price, the largest AO t-value was 8.27 (2008 Apr) and the largest TS t-value was 5.52 (2004 Jan) suggesting that AO and LS outliers are present (the critical absolute *t*-value for AO/LS was 4.05). These outliers were automatically adjusted in regARIMA for the monthly farm gate price series. For monthly retail price, no AO or LS was detected, and the combined trading day and leap year regressors were also not significant (*p*-value = 0.57).

The Forecast and Seasonal Adjustments

In order to assign symmetric weights to the original farm gate and retail price series, the regARIMA model part of the X-12 ARIMA program extended the series by one year ahead forecast. The forecast values of both farm gate and retail prices are presented in Tables 1a and 1b. The monthly forecast for retail price appears to perform better than the farm gate price in terms of error ratio and confidence interval coverage.

The seasonal adjustments

The decomposition results include the trend-cycle (TC), the seasonal factors (SF) and the irregulars (IR). The additive decomposition components of monthly farmgate and retail prices series exhibited clear upward trends and normal irregular variations (Fig. 5a and 5b). The secular or long term trend lines for both farmgate and retail prices of pork show that the market was on a clear uptrend. Livestock production and prices are characterized by more or less regular cycles, that is, production and prices have a tendency to move up and down over some period of years and this pattern repeats itself regularly regardless of outside forces. When production is increasing, prices are decreasing, holding other factors constant. After some time, these movements will reverse themselves such that production will decline and prices will move upward. These cycles can be explained by the tendency of the producers to make future plans to produce based on the profits gained from current or more recent past operations.

The seasonal factors on the other hand appeared to be stable. As with all agricultural markets, livestock markets are susceptible to seasonal variation (Norwood and Lusk 2008). From March to May, the seasonal factors are more than the seasonal average for the farmgate price of pork. In May, the seasonal index spiked, which could be due to strong market demand to celebrate several religious festivities during the month. On the contrary, the lowest seasonal index in November means that the farmgate price of pork was lower than the seasonal average. This could have been caused by the fact that swine raisers, in anticipation of the upcoming holiday season in December, increased their animal stock such that there is already so much supply in the market for which there is still not enough demand except for the few enterprising individuals who are into processing (e.g. ham, bacon, etc.). This notion was supported by the fact that by December the index started to pick up onwards January until the start again of the annual festivities in the country. Almost the same factors can be observed for the retail price of pork.

The other critical component of the price movement is the irregular component, which is unpredictable and corresponds to the movement that appears irregularly and generally during short periods. More volatile movement of monthly farmgate price of pork over time relative to the monthly retail price can probably be due to disease outbreaks. Swine is highly susceptible to diseases especially during inclement weather. Pigs need to be protected from extreme weather conditions and typhoons carry with them, most of the time, excessive rains and cold temperature and in some cases flooding. Frequent occurrence of typhoons may result to mortality and cause morbidity among pigs.

Table 1a. The forecasts of Philippines monthly farm gate price of pork in 2017.

Month	Forecast	Confidence interval (at 95%)	Std. Error
Jan	96.47	(93.55, 99.39)	1.5
Feb	97.30	(92.97, 101.63)	2.2
Mar	98.89	(93.50, 104.28)	2.8
Apr	99.35	(93.08, 105.61)	3.2
May	99.70	(92.67, 106.73)	3.6
Jun	99.59	(91.87, 107.32)	3.9
Jul	98.41	(90.05, 106.76)	4.3
Aug	97.39	(88.44, 106.34)	4.6
Sep	96.71	(87.20, 106.21)	4.8
Oct	97.23	(87.20, 107.25)	5.1
Nov	97.19	(86.66, 107.72)	5.4
Dec	98.59	87.59, 109.58)	5.6

Table 1b. The forecasts of Philippines monthly retail price of pork in 2017.

Month	Forecast	Confidence interval (at 95%)	Std. Error
Jan	168.90	(166.43, 171.37)	1.3
Feb	169.60	(165.67, 173.54)	2.0
Mar	170.82	(165.83, 175.81)	2.5
Apr	171.27	(165.42, 177.12)	3.0
May	172.38	(165.78, 178.99)	3.4
Jun	172.64	(165.36, 179.92)	3.7
Jul	172.78	(164.88, 180.68)	4.0
Aug	172.62	(164.14, 181.09)	4.3
Sep	172.31	(163.30, 181.32)	4.6
Oct	172.01	(162.49, 181.52)	4.9
Nov	172.22	(162.21, 182.22)	5.1
Dec	172.56	(162.10, 183.02)	5.3

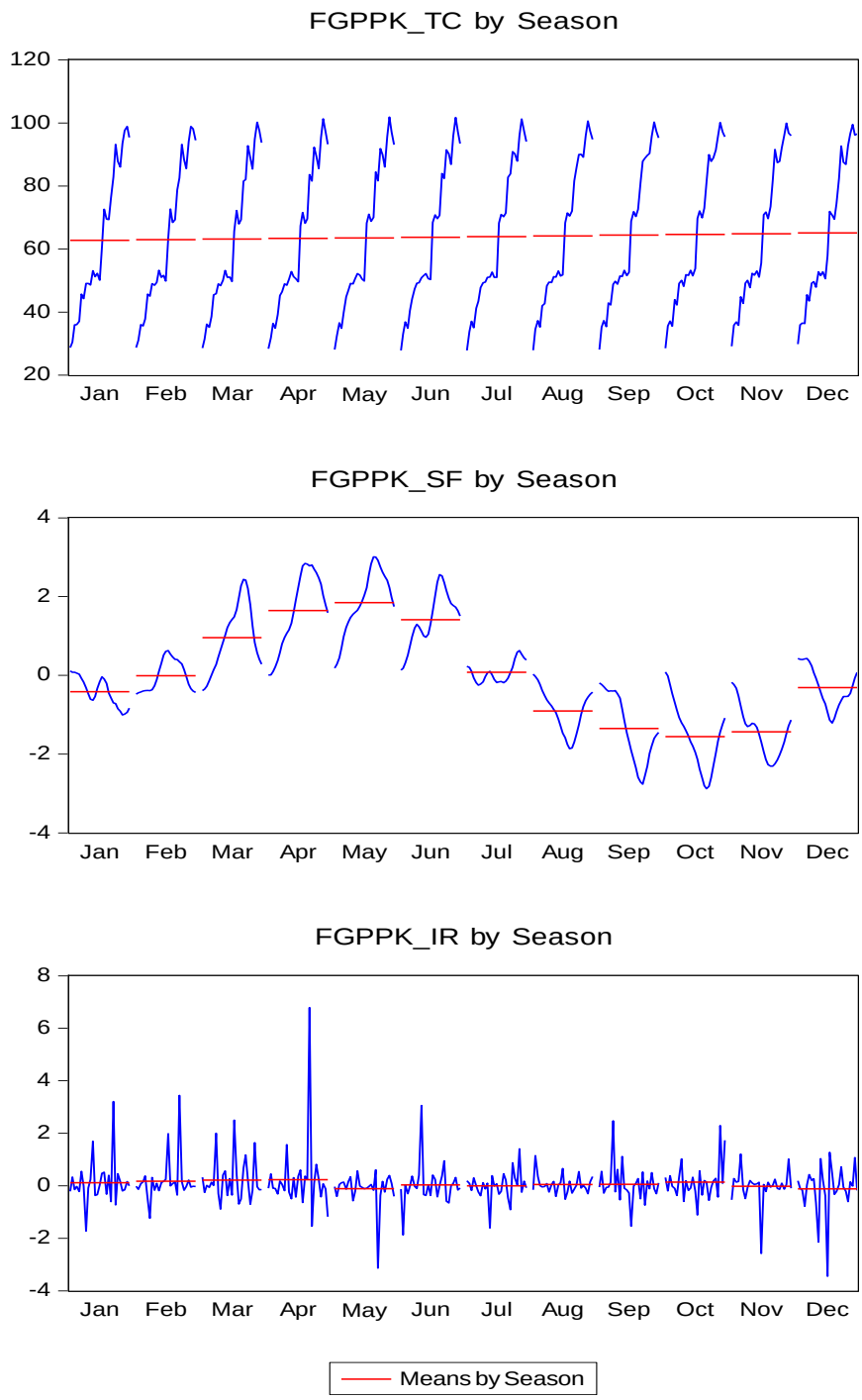

Fig. 5a. The additive components of monthly farm gate price of pork.

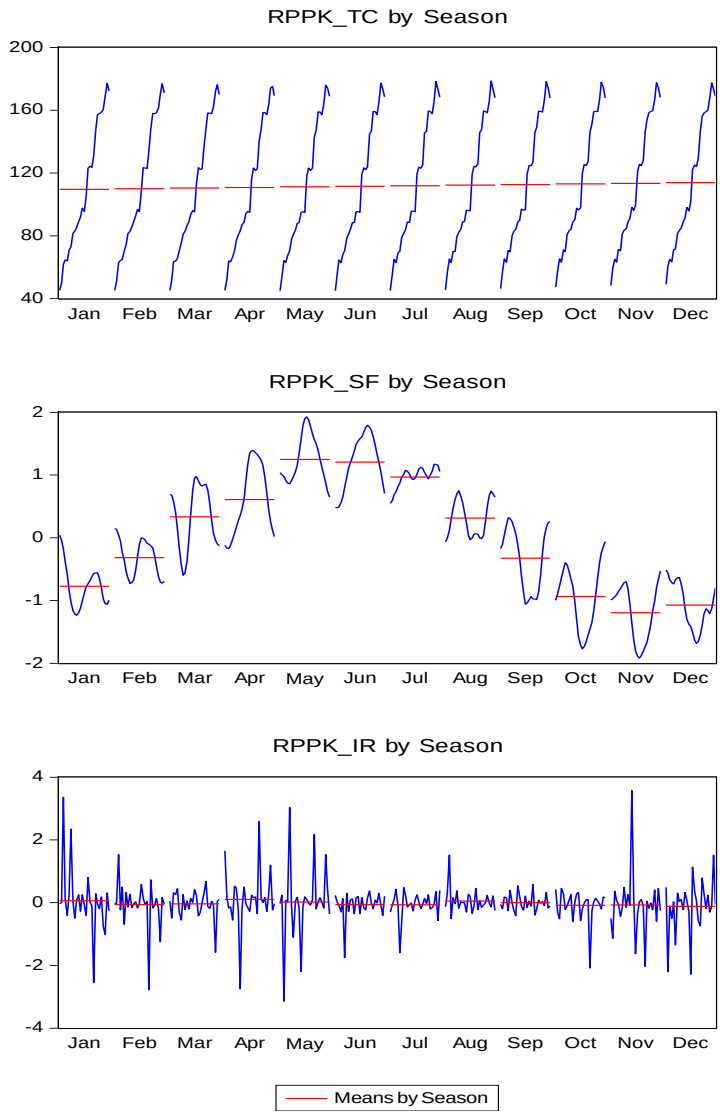

Fig. 5b. The additive components of monthly retail price of pork.

For seasonality to be regarded as present, the series should be identified as seasonal by using the "test for the presence of seasonality assuming stability" and "nonparametric test for the presence of seasonality assuming stability." Also, since the presence of moving seasonality can cause distortion, it is important to evaluate the moving seasonality in conjunction with the stable seasonality to determine whether the seasonality is identifiable. The test for identifiable seasonality was performed by combining the *F* tests for stable and moving seasonality, along with a Kruskal-Wallis test for stable seasonality.

The seasonality tests results are presented in Table 2. It can be seen that both monthly farmgate and retail prices of pork have stable seasonality along with moving seasonality at 1% level of probability. More critically, Q-statistic confirmed the seasonality for both farmgate and retail prices. Lastly, the diagnostic test for the presence of residual seasonality indicates that there was no evidence of residual seasonality in the entire series at the 1% level, nor in the last 3 years.

An interview with industry key informants revealed that in the Philippines, in the case of swine, seasonality in production is caused mainly by porcine epidemic diarrhea (PED) causing death among sows and piglets nearly depleting the existing stock and thus, practically reducing pork supply in the market. The United States Department of Agriculture (USDA, n.d.) reported that PED is most serious in neonatal piglets where morbidity and mortality can be 80 to 100%. So far, there is no effective treatment other than controlling secondary infections. The USDA has also reported that the Philippines is among the countries with cases of PED. The disease can only be directly transmitted through fecal-oral contamination but indirectly it can also spread through contaminated personnel, equipment, or any object, to susceptible herds. If chickens have avian flu, its equivalent in swine is PED. PED vaccines exist in Japan, South Korea and China but imported vaccines are not that effective in the local setting, hence the disease continues to cripple the country's swine industry. In addition, in China, because of three new PED variants discovered in 2011, the CV777-based vaccine is no longer effective (Li et al. 2012 as cited by the USDA, n.d.).

In addition, pork is one of the frequently smuggled agricultural commodities into the country such that when smuggled shipments reach the market, prices fall rendering the locally produced pork uncompetitive unless price at the farm gate is reduced contributing to fluctuations.

Table 2. The F-Tests for seasonality

Price	Test for Stable Seasonality*	Test for Moving Seasonality*	Kruskal-Wallis Statistic*	Combined Seasonality	Q-Statistic	Decision
Farm gate	Present	Present	Present	Identifiable	0.46	Accepted
Retail	Present	Present	Present	Identifiable	0.55	Accepted

*At 1% level of probability

CONCLUSION AND RECOMMENDATION

More frequently, agricultural products like swine are produced seasonally as they have natural agro-climatic requirements. Agricultural products are also highly perishable and thus are more prone to losses compared with manufactured products. These and other factors affect their price formation and, as such, their prices vary because of these components: trend-cycle, seasonal, and irregular.

The key results of the seasonally adjustment of monthly farm gate and retail prices were:

1. *t*-values of weekend regressor and leap year regressor were not significant;
2. Both price series exhibited clear steep upward trends and normal irregular variations;
3. Stable and moving seasonality were present in monthly farmgate price; the combined test for the presence of identifiable seasonality was identified at the 1% level of probability;
4. Stable and moving seasonality were present in monthly retail price; the combined test for the presence of identifiable seasonality was identified at the 1% level of probability;
5. There was no evidence of residual seasonality in the entire monthly price series of pork at the 1% level, nor in the last 3 years.

Knowledge of seasonal price changes provides a basis for determining the period of production for a more profitable sale. Records of past seasonal variations are important for farmers in determining the behavior of prices in the near future so that they will be able to adjust production in order to avoid selling their products during low periods. At the same time, they will be able to recognize and take advantage of some favorable price conditions in the market that usually offer opportunities for profit. These kinds of information may also be useful to policy-makers in the

formulation of specific policies and programs aimed at increasing or stabilizing the supply of pork. For instance, the government can take a closer look at how it is responding to the PED that is one of the major causes of swine death and morbidity in the country eventually resulting to pork price seasonality. Funding researches for vaccine development technology is a strategic but a long term strategy for swine industry improvement.

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