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Spillover effects of price volatility in the egg and meat markets in the Philippines

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Abstract

The study investigates the presence of price volatility and its spillovers in the markets of chicken eggs, duck eggs, chicken meat, pork and beef in the Philippines. An autoregressive conditionally heteroscedastic approach (ARCH) is used to generate the heat wave and meteor shower effects of price volatility, which measure the risks emanating from the fluctuating prices of the products in their own markets and their effects on other markets as well. Significant heat waves are detected in dressed chicken, chicken eggs, pork and beef, which indicate the presence of risks in their markets due to price uncertainty. On the other hand, all egg and meat markets in the study receive meteor showers, which may connote augmented price uncertainties in these markets. The findings imply that augmented price risks may hamper the operations of these markets towards efficiency and competitiveness. Thus, efficient market information services, cost-saving technological innovations and continued research are recommended to address the issues concerning volatile price movements for the benefit of the agricultural markets in the Philippines.

Keywords: price volatility, autoregressive conditionally heteroscedastic approach (ARCH), heat wave effect and meteor shower effect

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1. Introduction

Price volatility has a disruptive effect in the economy because it creates risks due to uncertainty as to the range within which prices may vary in the future (Weaver and Natcher, 2000 as cited by Rezitis, 2003). An indication of its presence suggests an amplified difficulty to deal with price changes, which renders commodity markets to lose their original function of trade and physical delivery of goods, and become suitable for speculative and hedging activities (Spargoli and Zagaglia, 2007). Agricultural markets are vulnerable to price volatility because their prices fluctuate sometimes unpredictably due to seasonality, inelastic demand and production uncertainty (Just et al., 1990, 1998; Holt and Moschini as cited by Rezitis and Stavropoulos, 2009).

Price volatility, in particular, is a big problem for commodity–dependent producers and countries because it would make escape from the cycle of commodity dependence impossible. With its presence, fiscal and development planning is made extremely difficult for both policymakers and market players (Brown et al., 2008); more so with its spillover effects where markets would face more nebulous planning horizons due to augmented uncertainties. The spillover effects tend to intensify market risks since imperfect market mechanisms/dynamics are usually aggravated. Thus, significant levels of price volatility spillovers increase the difficulty of markets to function efficiently and forecast reliably for the welfare of producers, consumers and other stakeholders.

Over the years, several studies have already pored over the dynamics of price volatility and its spillovers, but most of them are pertaining to the financial market; seldom to agriculture. For agriculture, thorough investigation on this aspect can be found in the works of Rezitis (2003), Benjamin et al. (2009) and Du et al. (2009) where evidences of volatility spillovers in agricultural markets were scientifically tested and recorded. In the study of Balanay (2011), significant time–varying price volatility was found uncontainable in the markets of the leading poultry products in the Philippines, which means the poultry industry in the country is faced with complicated repercussions of fluctuating poultry prices.

Spillover effects of volatile price movements complicate market risks. However, in Philippine agricultural markets, these spillover effects and risks are given less attention which mat explain why many agricultural markets in the country can hardly operate efficiently. In other countries, manifestations of price volatility are investigated extensively, particularly in meat markets, because meat products have been observed to illustrate volatile price movements distinctively (Rezitis and Stavropoulos, 2009).

In this study, the meat market in the Philippines is investigated along with the egg market to check its price volatility and associated repercussions. Pork and chicken are the leading meat products and protein sources in the Philippines, which fall under the industries of practically huge economic importance. Chicken meat is next to pork in popularity and is under poultry, which is considered as a prime mover of Philippine Agriculture since poultry constitutes 14% of the entire agricultural production in the country (Bureau of Agricultural Statistics, 2007 and US Department of Agriculture Foreign Agricultural Service, 2009). With this, the spillovers of the price volatilities of these products may have tremendous effects in other agricultural markets owing to their industry size and breadth of influence.

Engle, Ito and Lin (1990 as cited by Rezitis, 2003) call the spillovers of volatility as “heat wave” and “meteor shower” effects. In market context, heat wave effect is associated with a significant level of price uncertainty in a product’s own market, while meteor shower effect is a significant volatility spillover that may augment the price uncertainties in other markets (Rezitis, 2003). The emphasis of this study is to detect the presence of the spillovers and determine the implications of which across the egg and meat markets in the country. Studying the manifestations of price volatility and its spillovers have been a growing interest in market research because it can provide a great deal of insights to policymakers and stakeholders on the development of safety nets, such as hedging and price-stabilizing mechanisms that safeguard the interests of producers, consumers, and other stakeholders of commodity markets.

2. Literature review

Apprehensions generally escalate with spillover effects of market price fluctuations. The spillovers have the tendency to worsen the complexities of economic situations, making them difficult to handle for policymakers and stakeholders. Determining the risks of price volatility as categorized into intra–market or inter–market provides a way of predicting the consequences of unpredictable price changes. The case of egg and meat markets in the country is worth noting for in this aspect, as eventually strains on these markets would push for the control of any adverse effect relative to volatile price movements.

Price volatility studies are often conducted for financial market analysis, but are seldom undertaken for agricultural commodities because some of these commodities are protected by price support policies. However, over the years, price analysis has evolved into an area that recognizes the importance of studying volatile price movements in agricultural products with econometric methods similar to those used in financial market analysis. Particularly, Benjamin et l. (2009) using partial equilibrium and WEMAC 2.0 model had established the influence of crude oil price on the variation of crop prices involving cereals, main oilseeds and the products derived from the crushing of oilseeds. Du et al. (2009) studied the roles of various factors influencing the volatility of crude oil prices and the possible links between such volatility and agricultural commodity markets with stochastic volatility models. Such study yielded evidence of volatility spillover s among the product markets involved (crude oil, corn and wheat markets).

The study of Ramirez (2009) assessed whether asymmetric–cycle models can enhance the understanding of the dynamics and provide for a better forecasting of US soybean and Brazilian coffee prices. It utilized alternative threshold autoregressive (TAR) models that provided more precise forecasts than standard autoregressive models and useful insights on the markedly different dynamics of the upward versus the downward cycles in the prices of US soybeans and Brazilian coffee. Bekkerman and Pelletier (2009) had the volatility of hedging price risk investigated through a multivariate GARCH model. Results of the study indicated significant increase in “basis” volatility in some of the markets after 2006.

The use of ARCH in the estimation of price volatility and supply response is demonstrated in the study of Aradhyula and Holt (1990 and 1998, as cited by Rezitis and Stavropoulos, 2009). Aradhyula and Holt (in the paper of Rezitis and Stavropoulos, 2009) used price uncertainty and volatility in modeling supply and demand of the broiler market. They applied the generalized autoregressive conditional heteroskedasticity (GARCH) approach to generate time–varying predictions of supply and demand indicating that price volatility is an important risk factor in broiler supply.

Meanwhile, Rezitis and Stavropoulos (2009) examined the supply response of pork in the Greek market with GARCH to estimate expected price and price volatility. The price and supply equations were jointly estimated in their study. Aside from the standard GARCH model, symmetric, asymmetric and nonlinear GARCH models were estimated. In the paper of Rezitis and Stavropoulos (2009), the quadratic NAGARCH model was able to capture better the producers' price volatility, which became the risk factor in the supply response estimation for the Greek pork market. The findings of their paper showed that feed price was an important cost factor of the supply response function and that high uncertainty could restrict further development in the pork sector of Greece.

The study of Jordaan et al. (2007) utilized ARCH/GARCH approach in determining the conditional volatility in the daily spot prices of the crops traded on the South African Futures Exchange (SAFE). The findings of the study had identified the traded crops with more risks. The study then recommended that further research on the factors influencing the level of volatility and the factors influencing a change in the level of volatility must be pursued to reduce volatility in prices.

The study of Rezitis (2003) investigated with generalized ARCH (GARCH) the volatility spillover effects of the Greek consumer meat prices. Based on the analysis, price volatilities of lamb, beef, pork and poultry are across the Greek meat market. Heat wave and meteor shower effects in the study are positive and significant; indicating that the higher price volatility in one meat category increases the price volatility in others. The findings render the meat prices more volatile and able to augment market uncertainty and risk for the market participants.

3. Methodology

3.1. Data

The data consist of the monthly prices of the leading meat products (pork, dressed chicken and beef) as well as chicken and duck eggs from 1990 to 2009. These are obtained from the Bureau of Agricultural Statistics (BAS) and its online information service at Countrystat website. The prices of the said commodities are deflated with the monthly consumer price index (CPI) from 1990 to 2009 with July 2000 as the base period. The CPI values are obtained from the National Statistical and Coordination Board (NSCB) in the Philippines.

3.2. Econometric approach and model specification

The study had used a two-stage estimation approach in determining the presence of volatility spillovers as heat wave and meteor shower effects in the markets of dressed chicken, pork, beef, chicken eggs, and duck eggs. The analysis is anchored mostly on understanding the generated variances from the error-corrected models of the said products.

Descriptive statistics (mean, standard deviation, skewness, kurtosis, normality of distribution and correlation), Augmented Dickey–Fuller and Johansen cointegration tests precede the series of analysis performed for the product prices in the study. The former describes the distribution of the monthly price data in the series. The second test determines the presence of unit roots, which indicates whether the effect of any shock is permanent or not (Maddala, 1992). The use of ADF test is related to the correlated error terms of the estimating equations, which need a sufficient number of lagged difference terms of the dependent price variable. This is necessary to make the error terms serially uncorrelated (Gujarati, 2004). On the other hand, if the data series is I(1), it is worth to check for cointegration in the series to discern whether or not model adjustment is necessary. Significant cointegrated relationships merit the application of an error correction model (ECM) in the analysis.

The Johansen cointegration test determines whether cointegrated relationships exist among the variables in the model. If the variables are found cointegrated, adjustment of the original model is necessary so that spurious results will be avoided. According to Greene (2003), mere differencing of data is counterproductive because the true long–run relationships are still obscured. Error–correction factors are the relevant adjustments to be integrated in the models to preserve and manifest the true long–run relationships in the analysis of the data series.

After the preliminary tests, the autoregressive conditional heteroscedastic (ARCH) approach is applied with the commodity price changes as the dependent variable in the mean equations as shown in the specified models below. The approach is mainly to determine the heat wave and meteor shower effects through the variance equations of the test results. According to Engle (2001), the ARCH model is a weighted average of past squared residuals, where the weights are declining but can never be equal to zero. His paper has described its associated models to be parsimonious and easy to estimate but successful in predicting conditional variances even in the simplest form. The most widely–used ARCH specification has identified the best predictor of the variance in the next period as comprised of the weighted average of the long–run average variance, the variance predicted for this period, and the new information in this period that is captured by the most recent squared residual. Such updating rule is a simple description of adaptive or learning behaviour, which can be of Bayesian characteristic (Engle, 2001).

Based on the work of Rezitis (2003), the model for the analysis is also specified as

$$\Delta P_t^{c} = a_0 + \sum_i a_{1i}\Delta P_{t-i}^{c} + \sum_i a_{2i}\Delta P_{t-i}^{ce} + \sum_i a_{3i}\Delta P_{t-i}^{de} + \sum_i a_{4i}\Delta P_{t-i}^{p} + \sum_i a_{5i}\Delta P_{t-i}^{b} + \varphi_1\mu_{t-1} + \varepsilon_t^{c}$$

$$\Delta P_t^{ce} = a_0 + \sum_i a_{1i}\Delta P_{t-i}^{ce} + \sum_i a_{2i}\Delta P_{t-i}^{c} + \sum_i a_{3i}\Delta P_{t-i}^{de} + \sum_i a_{4i}\Delta P_{t-i}^{p} + \sum_i a_{5i}\Delta P_{t-i}^{b} + \varphi_2\mu_{t-1} + \varepsilon_t^{ce}$$

$$\Delta P_t^{de} = a_0 + \sum_i a_{1i}\Delta P_{t-i}^{de} + \sum_i a_{2i}\Delta P_{t-i}^{c} + \sum_i a_{3i}\Delta P_{t-i}^{ce} + \sum_i a_{4i}\Delta P_{t-i}^{p} + \sum_i a_{5i}\Delta P_{t-i}^{b} + \varphi_3\mu_{t-1} + \varepsilon_t^{de}$$

$$\Delta P_t^{p} = a_0 + \sum_i a_{1i}\Delta P_{t-i}^{p} + \sum_i a_{2i}\Delta P_{t-i}^{c} + \sum_i a_{3i}\Delta P_{t-i}^{ce} + \sum_i a_{4i}\Delta P_{t-i}^{de} + \sum_i a_{5i}\Delta P_{t-i}^{b} + \varphi_4\mu_{t-1} + \varepsilon_t^{p}$$

$$\Delta P_t^{b} = a_0 + \sum_i a_{1i}\Delta P_{t-i}^{b} + \sum_i a_{2i}\Delta P_{t-i}^{c} + \sum_i a_{3i}\Delta P_{t-i}^{ce} + \sum_i a_{4i}\Delta P_{t-i}^{de} + \sum_i a_{5i}\Delta P_{t-i}^{p} + \varphi_5\mu_{t-1} + \varepsilon_t^{b}$$

$$h_t^c = l_0 + l_1\varepsilon_{t-1}^{c\,2} + l_2 h_{t-1}^c + l_3 h_{t-1}^{ce} + l_4 h_{t-1}^{de} + l_5 h_{t-1}^p + l_6 h_{t-1}^b$$
$$h_t^{ce} = k_0 + k_1\varepsilon_{t-1}^{ce\,2} + k_2 h_{t-1}^{ce} + k_3 h_{t-1}^c + k_4 h_{t-1}^{de} + k_5 h_{t-1}^p + k_6 h_{t-1}^b$$
$$h_t^{de} = m_0 + m_1\varepsilon_{t-1}^{de\,2} + m_2 h_{t-1}^{de} + m_3 h_{t-1}^c + m_4 h_{t-1}^{ce} + m_5 h_{t-1}^p + m_6 h_{t-1}^b$$
$$h_t^p = n_0 + n_1\varepsilon_{t-1}^{p\,2} + n_2 h_{t-1}^p + n_3 h_{t-1}^c + n_4 h_{t-1}^{ce} + n_5 h_{t-1}^{de} + n_6 h_{t-1}^b$$
$$h_t^b = p_0 + p_1\varepsilon_{t-1}^{b\,2} + p_2 h_{t-1}^b + p_3 h_{t-1}^c + p_4 h_{t-1}^{ce} + p_5 h_{t-1}^{de} + p_6 h_{t-1}^p$$

where $\Delta P_t^c, \Delta P_t^{ce}, \Delta P_t^{de}, \Delta P_t^p$ and ΔP_t^b are the first differences of retail prices for chicken meat (dressed chicken and live broiler), chicken eggs, duck eggs, pork and beef. On the other hand, $\varphi_1, \varphi_2, \varphi_3, \varphi_4$ and φ_5 are the adjustment coefficients of the retail prices of the same products and μ_{t-1} is the lagged value of the error correction term derived from the long–run cointegrating relationship between the four prices. $\varepsilon_t^c, \varepsilon_t^{ce}, \varepsilon_t^{de}$, ε_t^p and ε_t^b are the residuals of the mean process of the retail prices of chicken meat (dressed chicken and live broiler), chicken eggs, duck eggs, pork and beef, respectively. $h_t^c, h_t^{ce}, h_t^{de}, h_t^p$ and h_t^b are the conditional variance equations of chicken meat (dressed chicken and live broiler), chicken eggs, duck eggs, pork and beef, respectively. In these equations, l_2, k_2, m_2, n_2 and p_2 are the heat wave effects of the price volatility on chicken meat, chicken eggs, duck eggs, pork and beef, respectively. The meteor shower effects are captured by the other parameters, i.e. l_3, l_4, l_5 and l_6 are the volatility spillover effects of chicken eggs, duck eggs, pork and beef on chicken meat (dressed chicken or live broiler). The persistence measurements are derived from the parameters of the conditional variances. These measurements refer to the sums of the regression coefficients in the conditional variance equations, i.e. $l_1 + l_2 + l_3 + l_4 + l_5 + l_6$ and so on. If the sum is less than one, then the ARCH model is valid or stationary. But if a sum equals one, then the volatility is infinite (Rezitis, 2003).

4. Results and discussion

The descriptive statistics of the price series (in log form) is shown in Tables 1 and 2. The price series are mostly negatively skewed and leptokurtic relative to normal distribution, which suggests that the series (in log form) have fatter tails and more acute peaks around the mean. Based on Jarque-Bera test, normality is rejected in all series at 1% level of confidence. Table 2 shows the indication of interdependence among the markets in this study, where all price series are found highly correlated. On the other hand, Figure 1 reports the behavior of the residuals of the prices, in which time-varying volatility is implied. In product markets, time-varying volatility signifies unpredictability of price changes, which is associated with price risks.

4.1. Stationarity of the price series and integration analysis

Table 3 presents the results of the ADF test for the price series (in log) of the egg and meat products. The results show that stationarity in the series is obtained at the first and second differences. Thus, the integration level would be I(1) for the volatility spillover analysis, which also indicates the need to check for cointegration. The test for co-integration is shown in Table 4, where the Johansen test results depict at least four vectors in the price series to be cointegrated. The results suggest that true long–run relationships are present among the series to be analyzed, which must be preserved by integrating an error correction factor. The error correction factor adjusts the estimates to avoid spurious results in later estimations, and has a profound economic meaning depicting the feedback mechanisms among the product markets. The presence of cointegrating relationships and the estimation adjustment through the error correction factor justify the use of the error correction model (ECM) in investigating the spillover effects of price volatility in the egg and meat markets in the Philippines.

Table 1. Descriptive Statistics of the Price Series, Philippines, 1990-2009

Parameters	Dressed Chicken	Live Broiler	Pork	Beef	Chicken Eggs	Duck Eggs
Mean	4.404	4.184	4,582	4.851	1.064	1.278
Median	4.404	4.155	4.627	4.833	1.090	1.327
Standard Deviation	0.318	0.320	0.387	0.348	0.355	0.374
Skewness	-0.136	0.036	-0.137	0.0000043	-0.186	-0.229
Kurtosis	1.761	1.701	1.494	1.550	1.600	1.528
Jarque- Bera	16.102	16.852	23.434	21.037	20.997	23.775
Prob.	0.000	0.000	0.000	0.000	0.000	0.000

Table 2. Correlation Matrix of the Monthly Price Series, Philippines, 1990-2009

	Correlation Matrix					
Products	Beef	Chicken Eggs	Dressed Chicken	Duck Eggs	Live Broiler	Pork
Beef	1.000000	0.979184	0.984021	0.980536	0.985367	0.989337
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Chicken Eggs	0.979184	1.000000	0.984626	0.986534	0.973804	0.980509
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Dressed Chicken	0.984021	0.984626	1.000000	0.981016	0.981016	0.976781
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Duck Eggs	0.980536	0.986534	0.981016	1.000000	0.972928	0.986210
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Live Broiler	0.985367	0.973804	0.991005	0.972928	1.000000	0.973996
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pork	0.989337	0.980509	0.976781	0.986210	0.973996	1.000000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Figures in parentheses are t-values for the level of significance

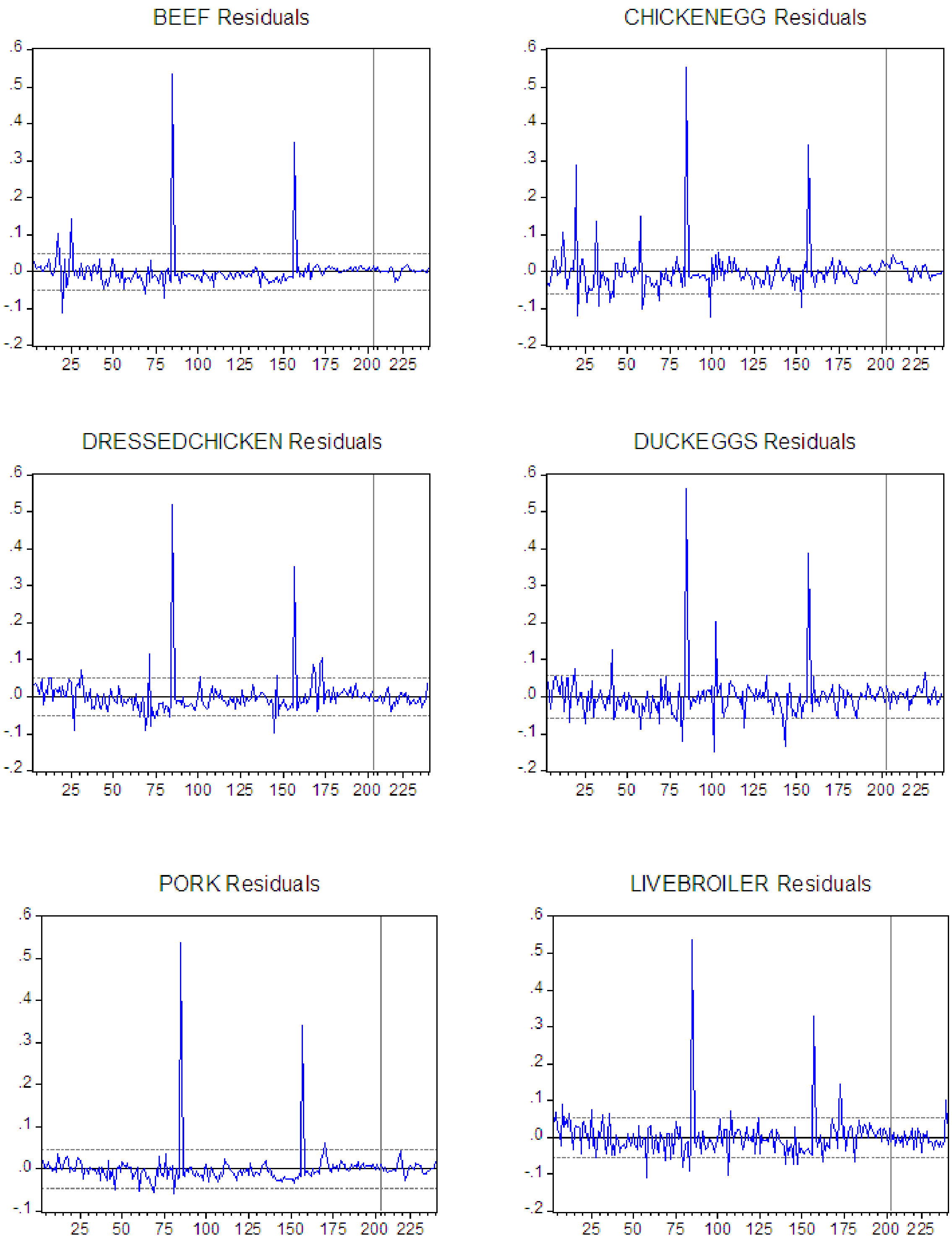

Figure 1. The Behavior of the Residuals in the Price Series

Table 3. Augmented Dickey – Fuller (ADF) Test Results for Stationarity of the Prices Series, Philippines, 1990 – 2009

Variables	*L*	*FD*	*SD*
Monthly real price of chicken (broiler live)	-2.64	-7.82**	-9.64**
Monthly real price of chicken (fully dressed)	-2.34	-7.48**	-9.94**
Monthly real price of chicken egg	-2.35	-8.74**	-12.0**
Monthly real price of duck egg	-2.58	-4.34**	-9.77**
Monthly real price of pork	-2.14	-5.54**	-8.10**
Monthly real price of beef	-1.53	-4.79**	-8.13**

*Note: **indicates rejection of null hypothesis of non – stationarity at 5% level of significance*
L represents level form
FD represents first difference
SD represents second difference

Table 4. Johansen Test for Co-Integration of Price Variables for Volatility Spillover Estimation, Philippines, 1990 – 2009

	Trace Statistics					
Commodity	*k = 0*	*k ≤ 1*	*k ≤ 2*	*k ≤ 3*	*k ≤ 4*	*k ≤ 5*
Live broiler chicken (12)	123.88**	85.82**	54.17**	30.10**	11.84**	
	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)	
Fully dressed chicken (12)	127.42**	88.19**	53.48**	30.36**	12.98**	
	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)	
Chicken egg (12)	161.41**	121.63**	85.11**	56.09**	31.23**	14.27**
	(95.75)	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)
Duck egg (12)	161.41**	121.63**	85.11**	56.09**	31.23**	14.27**
	(95.75)	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)
Pork (12)	161.41**	121.63**	85.11**	56.09**	31.23**	14.27**
	(95.75)	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)
Beef (12)	161.41**	121.63**	85.11**	56.09**	31.23**	14.27**
	(95.75)	(69.82)	(47.86)	(29.80)	(15.49)	(3.84)

The Trace test was used to test the null hypothesis that the number of cointegrating vectors is less than or equal to k, where k is equal to 0 to 6
*** Indicates that the null hypothesis is rejected at the 5% level*
The critical values at the 5% level are shown in parentheses below test statistic.

4.2. Volatility spillover analysis in the egg and meat markets

The results of volatility spillover analysis are presented in two parts for each product. The upper part contains the parameters in the mean equation or the factors of price change in a product market; while the lower part exhibits the volatility spillover effects or the heat wave and the meteor shower effects in the variance equation.

4.3. Dressed chicken and live broiler

The factors contributing to the changes in the prices of dressed chicken are many compared to that of live broiler (Tables 5 and 6). Aside from the feedback mechanisms represented by the error correction factor in the mean equation, both markets have price changes influenced by their historical rates of change and by that of duck eggs. In addition, the rates at which the dressed chicken price changes are also affected by the price changes in beef and pork.

Table 5. Volatility Spillover Effects for Dressed Chicken, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std .Error*	*z-Statistic*
	Mean Equation		
Constant	-0.0012	0.0015	-0.8027
Lagged real price of dressed chicken (Δ)	0.6995***	0.1582	4.4204
Lagged real price of chicken egg (Δ)	-0.0311	0.0289	-1.0756
Lagged real price of duck egg (Δ)	-0.0739***	0.0184	-4.0093
Lagged real price of pork (Δ)	-0.2032***	0.0684	-2.9694
Lagged real price of beef (Δ)	0.0998**	0.0459	2.1760
Error-correction	-0.6230***	0.1810	-3.4420
	Variance Equation		
Constant	0.0003***	0.0000	9.6283
ARCH(1)	0.8405***	0.1535	5.4739
Lagged real price of dressed chicken (Δ)	0.0068**	0.0030	2.2827
Lagged real price of chicken egg (Δ)	-0.0006	0.0010	-0.5731
Lagged real price of duck egg (Δ)	0.0028***	0.0004	7.1898
Lagged real price of pork (Δ)	0.0021	0.0016	1.3363
Lagged real price of beef (Δ)	0.0018	0.0014	1.3058
R-squared	0.1151		
N	238		
Persistence measurement	0.8534		

Note: ****significant at 1%*
***significant at 5%*

This signifies the interdependence of these products and their being close substitutes as protein source. A unit increase in the change of price of duck eggs and pork lowers the price increase in dressed chicken. A similar trend is true with the live broiler. Beef's price increase, however, did not decrease the increment in the price of dressed chicken, which indicates no close substitution possible between them. A significant heat wave is present in the dressed chicken market, implying that its price uncertainty is considerable and is augmented by the price uncertainty from duck eggs (meteor shower effect) as shown by the significant coefficient of duck eggs in the variance equation. The live broiler on the other hand has no heat wave but is challenged by the increased price uncertainty from the beef market. Both products (dressed chicken and live broiler) have persistence measurements of less than one, which validates the use of ARCH in the estimation process and implies that the volatility experienced is not infinite.

Table 6. Volatility Spillover Effects for Live Broiler, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std. Error*	*z-Statistic*
	Mean Equation		
Constant	-0.0004	0.0022	-0.1844
Lagged real price of live broiler chicken (Δ)	0.6053***	0.1445	4.1886
Lagged real price of chicken egg (Δ)	0.0828	0.0513	1.6143
Lagged real price of duck egg (Δ)	-0.1509***	0.0544	-2.7719
Lagged real price of pork (Δ)	0.0992	0.1469	0.6757
Lagged real price of beef (Δ)	-0.1052	0.0846	-1.2446
Error-correction	-0.9483***	0.1596	-5.9435
	Variance Equation		
Constant	0.0010***	0.0001	9.2942
ARCH(1)	-0.0231	0.0449	-0.5143
ARCH(2)	0.1239**	0.0606	2.0437
Lagged real price of live broiler chicken (Δ)	0.0028	0.0028	0.9953
Lagged real price of chicken egg (Δ)	0.0031	0.0032	0.9672
Lagged real price of duck egg (Δ)	-0.0026	0.0026	-0.9952
Lagged real price of pork (Δ)	-0.0019	0.0063	-0.2995
Lagged real price of beef (Δ)	0.0137***	0.0046	3.0088
R-squared	0.1642		
N	238		
Persistence measurement	0.1160		

Note: ****significant at 1%*
***significant at 5%*

4.4. Chicken eggs and duck eggs

The price changes in chicken and duck eggs are influenced only by a few factors: own historical price movements and feedback mechanisms (error correction factor) for chicken eggs, while feedback mechanisms only for duck eggs (Tables 7 and 8). This is indicative of a bit of independence in the process of price formation, and is possible when the markets are backed by strong demand in the economy. However, volatility spillovers are present in the two egg markets with chicken eggs having both heat wave and meteor shower effects. The meteor shower effects of chicken eggs are induced by the price uncertainties of live broiler, pork and beef. Specifically, the effects from live broiler and beef are risk-augmenting, while that of pork is risk-reducing. The duck eggs receive a risk-reducing volatility spillover from chicken eggs. Risk-reducing spillovers imply that the increase in price volatility in one market benefits the other market, possibly because of consequent demand shifts in favor of the other market. Similarly, the persistence measurement is less than one, which means volatility is not infinite and ARCH is valid in the estimation process.

Table 7. Volatility Spillover Effects for Chicken Egg, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std. Error*	*. z-Statistic*
		Mean Equation	
Constant	-0.0018	0.0024	-0.7428
Lagged real price of chicken egg (Δ)	0.7744***	0.1427	5.4287
Lagged real price of dressed chicken (Δ)	-0.0528	0.0988	-0.5345
Lagged real price of live broiler chicken (Δ)	0.1055	0.0680	1.5526
Lagged real price of duck egg (Δ)	-0.0447	0.0587	-0.7618
Lagged real price of pork (Δ)	-0.1612	0.1596	-1.0104
Lagged real price of beef (Δ)	0.1752	0.1242	1.4101
Error-correction	-0.7235***	0.1481	-4.8842
		Variance Equation	
Constant	0.0007***	0.0001	10.2643
ARCH(1)	0.3340***	0.0707	4.7238
Lagged real price of chicken egg (Δ)	0.0064**	0.0027	2.4145
Lagged real price of dressed chicken (Δ)	0.0004	0.0024	0.1817
Lagged real price of live broiler chicken (Δ)	0.0041**	0.0017	2.3564
Lagged real price of duck egg (Δ)	0.0008	0.0026	0.3079
Lagged real price of pork (Δ)	-0.0122***	0.0032	-3.8020
Lagged real price of beef (Δ)	0.0115**	0.0050	2.3040
R-squared	0.0764		
N	238		
Persistence measurement	0.3451		

Note: ****significant at 1%*
***significant at 5%*

4.5. Pork and beef

Tables 9 and 10 show the factors that influence the price changes in pork and beef. Besides error correction, the historical price fluctuations of pork have a strong influence over the fluctuations in its own price and also in beef's. Based on the mean equation in Table 10, beef's prices tend to imitate the movement of pork's prices, since the lagged real price of pork is positively signed in the estimation. However, the markets of beef and pork are faced with heat wave effects. The meteor shower effect in pork is induced by the price uncertainty in the beef market, but is risk-reducing in the sense that demand will shift in its favor when the beef market is not going to function well. Nevertheless, the meteor shower effect in beef is a challenge because its price uncertainty is to be augmented by the price risks in poultry market. The persistence measurement is also less than one, which means finite volatility and valid application of ARCH in the estimation.

Table 8. Volatility Spillover Effects for Duck Egg, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std. Error*	*z-Statistic*
	Mean Equation		
Constant	-0.0023	0.0025	-0.9062
Lagged real price of duck egg (Δ)	0.1320	0.1139	1.1589
Lagged real price of dressed chicken (Δ)	0.0915	0.0771	1.1861
Lagged real price of live broiler chicken (Δ)	-0.0405	0.0711	-0.5689
Lagged real price of chicken egg (Δ)	0.0076	0.0522	0.1454
Lagged real price of pork (Δ)	-0.1019	0.2046	-0.4983
Lagged real price of beef (Δ)	-0.0169	0.1093	-0.1546
Error-correction	-0.6281***	0.1177	-5.3374
	Variance Equation		
Constant	0.0009***	0.0001	8.7586
ARCH(1)	0.2498***	0.0699	3.5745
Lagged real price of duck egg (Δ)	-0.0024	0.0035	-0.6962
Lagged real price of dressed chicken (Δ)	0.0031	0.0032	0.9714
Lagged real price of live broiler chicken (Δ)	-0.0003	0.0031	-0.0840
Lagged real price of chicken egg (Δ)	-0.0035**	0.0017	-2.1174
Lagged real price of pork (Δ)	0.0006	0.0071	0.0889
Lagged real price of beef (Δ)	0.0002	0.0051	0.0344
R-squared	0.3154		
N	238		
Persistence measurement	0.2475		

Note: ****significant at 1%*
***significant at 5%*

Table 9. Volatility Spillover Effects for Pork, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std. Error*	*z-Statistic*
	Mean Equation		
Constant	-0.0002	0.0009	-0.1892
Lagged real price of pork (Δ)	1.2098***	0.2154	5.6152
Lagged real price of dressed chicken (Δ)	-0.0393	0.0328	-1.1969
Lagged real price of live broiler chicken (Δ)	0.0234	0.0243	0.9619
Lagged real price of chicken egg (Δ)	-0.0057	0.0254	-0.2229
Lagged real price of duck egg (Δ)	0.0149	0.0218	0.6852
Lagged real price of beef (Δ)	0.0060	0.0535	0.1121
Error-correction	-0.9390***	0.2342	-4.0085
	Variance Equation		
Constant	0.0001***	0.0000	8.5320
ARCH(1)	0.2265**	0.0921	2.4606
Lagged real price of pork (Δ)	0.0029***	0.0011	2.6452
Lagged real price of dressed chicken (Δ)	0.0004	0.0005	0.7492
Lagged real price of live broiler chicken (Δ)	0.0002	0.0003	0.7166
Lagged real price of chicken egg (Δ)	0.0000	0.0004	-0.0159
Lagged real price of duck egg (Δ)	0.0002	0.0004	0.5701
Lagged real price of beef (Δ)	-0.0010***	0.0003	-3.6121
R-squared	0.1745		
N	238		
Persistence measurement	0.2291		

*Note: ***significant at 1%*
***significant at 5%*

5. Conclusion and recommendations

The meat market in the Philippines is consistent with the observation of Rezitis (2003) in the presence of price volatility and its spillovers. The egg market is also similar with the meat market where price volatility cannot be contained. All product markets in this study are faced with risks associated with unpredictable price movements, which may augment the risks in other markets. Since price volatility is not a phenomenon that guarantees welfare improvement among market stakeholders, it must be investigated and addressed properly. Thorough analysis on the interconnectivity of products in the market helps in the process of finding more effective leverages that would not necessarily be about speculation and hedging. Availability of price information will help also, but a more practical approach of minimizing price volatility is by way of innovation where potentials of agricultural products (e.g. meat) will be harnessed and demand is created through the process. Cost-saving technologies can provide a buffer to the consequences of price volatility, which involves decision paralysis, the tendency of not taking risks among the producers to explore new products, processes and markets, and engage in long-term planning for diversification and expansion.

Table 10. Volatility Spillover Effects for Beef, Philippines, 1990 – 2009

Variables	*Coefficient*	*Std. Error*	*z-Statistic*
		Mean Equation	
Constant	-0.0009	0.0015	-0.6103
Lagged real price of beef (Δ)	-0.0258	0.2130	-0.1213
Lagged real price of dressed chicken (Δ)	-0.0353	0.0371	-0.9508
Lagged real price of live broiler chicken (Δ)	-0.0150	0.0347	-0.4318
Lagged real price of chicken egg (Δ)	-0.0316	0.0290	-1.0905
Lagged real price of duck egg (Δ)	-0.0077	0.0240	-0.3211
Lagged real price of pork (Δ)	0.3988***	0.0759	5.2548
Error-correction	-0.3995*	0.2192	-1.8228
		Variance Equation	
Constant	0.0002***	0.0000	9.5221
ARCH(1)	0.0983*	0.0510	1.9282
ARCH(2)	0.0903*	0.0514	1.7581
Lagged real price of beef (Δ)	0.0058***	0.0011	5.1496
Lagged real price of dressed chicken (Δ)	0.0017*	0.0010	1.6613
Lagged real price of live broiler chicken (Δ)	-0.0010	0.0007	-1.4181
Lagged real price of chicken egg (Δ)	0.0012***	0.0004	2.7123
Lagged real price of duck egg (Δ)	-0.0004	0.0003	-1.4798
Lagged real price of pork (Δ)	0.0006	0.0011	0.6028
R-squared	0.1818		
N	238		
Persistence measurement	0.1965		

Note: ****significant at 1%*
**significant at 10%*

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