PRODUCERS' BEHAVIOR TOWARDS CLIMATE AND PRICE RISKS: THE CASE OF POULTRY IN NORTHERN MINDANAO, PHILIPPINES

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ABSTRACT

The study investigates the presence of climate and price risks in the poultry industry of Northern Mindanao, Philippines, specifically the effects of these risks on producers' behavior. The empirical analysis uses autoregressive conditionally heteroscedastic (ARCH) approach in determining the significance of risks due to volatile price and climate oscillation with the use of monthly price data and monthly rainfall and mean temperature data from 1994-2011. Error-corrected supply response model was used to determine producers' behavior towards the said risks as represented by expected variance values in the model for policy interventions towards strengthening industry competitiveness and adaptive capacity. Over the period of 1994-2011, the significance of risks due to price volatility and unpredictable changes in rainfall and mean temperature was detected in the poultry industry of Northern Mindanao in the Philippines. This indicates that poultry producers and consumers would have some difficulty in making decisions for their benefit. Among these risks, the risk due to changes in climatic parameters (rainfall and mean temperature) is found to be stronger than the risk due to changes in prices. Poultry producers have the possibility to develop risk aversion due to unpredictable climatic condition, particularly in the production of dressed chicken and chicken eggs. Science and technology-based interventions to include efficient decision-support systems for economic and climate monitoring, genetic upgrading to improve poultry breeds, production insurance, product processing and efficient storage and post-production systems are recommended to enable the poultry industry to sustain its economic benefits and competitiveness.

Key Words: *price volatility, climate risk, risk aversion, ARCH and supply response*

Introduction

Climate change is a defining phenomenon of the 21st century (Tol, 2008). It is definitely an environmental issue that has significant implications on development, particularly in agriculture. Issues on vulnerability heighten with it because exposure to both gradual change phenomenon and extreme events is unavoidable, making the poor and developing nations face a difficult time in coping with adverse impacts due to lack of institutional and financial capacity. In the study conducted for Bangladesh, vulnerability to climate change is well recognized for similar reasons (Rahman et al., 2009).

The World Bank (2007) as cited by Caldazilla et al. (2009) has identified the changes in temperature, precipitation, carbon dioxide fertilization, climate variability and surface water runoff as the climate change impacts that could severe the agriculture sector. Significantly, disastrous events could rise, which would have serious implications on the same sector as well as on capital stock and migration. Agricultural markets would be affected with these impacts since market risks are being induced. Nam Tran et al. (2012) have predicted the negative effects of climate change through the rise in price volatility in commodity markets.

Price volatility represents the risks that jeopardize the competitiveness and efficiency of commodity markets. It can dampen the risk-taking behavior of business individuals and organizations, due to unpredictable price movements and confounding market situations. It is pronounced in most meat markets (Rezitis, and Stavropoulos, 2009) and in markets highly dependent on climatic and biological processes. Balanay (2011) has corroborated the presence of which in the poultry markets of the Philippines. Thus, both forces (climate oscillation and price volatility) may usher in enormous problems in agricultural markets, because agricultural producers may tend to delay innovative and more efficient changes under the circumstances.

Analysis on price volatility and climate oscillation is important, therefore, as a way of determining the actions towards strengthening agricultural markets for welfare reasons. In the Philippines, the said markets are inevitably exposed to these risks that are not yet studied well. Thus, this study looks into the risks associated with the changing prices and climate and the implications of which on producer’s behavior, with special emphasis on a competitive region in the Philippines on poultry production.

Northern Mindanao is a major agricultural region in the country, with Cagayan de Oro as its capital city and major convergence point for poultry and other agricultural products. It has undergone a devastating experience with Typhoon Sendong in 2011, which the locals attributed to the impacts of climate change. With the region’s impact on Philippine agriculture, this study has done an analysis on the risks associated with price volatility and climate oscillation to determine their impacts as well on poultry supply in the country. Developing evidence-based interventions to enhance the adaptive capacity and development of the poultry market is deemed pressing for Northern Mindanao, Philippines to sustain its agricultural performance.

Literature Review

Impacts of climate change on agriculture can be found in many research works already such as those generated by Cunha et al. (2012) for Brazil, Dono (2012) for the Mediterranean area, Hertel and Rosch (2010) and Deressa et al. (2008) for Ethiopia, You et al. (2005) for Chinese wheat agriculture, Akpalu, Hassan and Ringler (2008) for maize in South Africa, and Ringler et al. (2010) for food security in Sub-Saharan Africa. A number of varied approaches have been used in these studies to evaluate empirically climate change impacts and some of the approaches are reviewed herein to comprehend the disturbing consequences felt already in agriculture that has supported vastly the population and economies across the world.

Dono et al. (2012) had made use of the net evapotranspiration (ETn) estimated with the EPIC model in analyzing the productive and economic impacts of climate change that is an unprecedentedly large, complex and uncertain externality (Tol, 2008). The method was intended to obtain a synthetic index of the physical factors that the farmer considers in decisions on the aspect of irrigation. The probability distribution of ETn was inserted into a territorial model of discrete stochastic programming that represented farm choices in conditions of uncertainty about water availability and irrigation requirements of crops, in which modifications on the physical factors could amplify the uncertainty of management and consequently, the costs incurred by the farm types in the irrigated Mediterranean area. The farm types may suffer in many cases an appreciable drop in income.

Kingwell (2006) reported that projected climate change in Australia would be spatially and temporally diverse, with many regions likely to experience increased downside risk in agricultural production. The farmers are likely to face additional costs of capital adjustment due to climate change. In addition, her study determined that investment in long-lived climate-dependent agricultural assets such as infrastructure, vineyards and agroforestry as well as investments in ecological assets in rural regions will become problematic. In the study of Oktaviani et al. (2011), climate change was noted to influence the economic performance of all countries in the world to include all economic sectors. For Indonesia, agriculture was reported to be the hardest hit sector in terms of the number of poor affected. The study made use of computable general equilibrium (CGE) model in determining the effects of climate change in the Indonesian economy. The results of which include a negative GDP growth as due to the adverse impacts of climate change (whose climate parameters are obtained from IFPRI's International Model for Policy Analysis of Agricultural Commodities and Trade), which affects greatly rice production. With food price shocks, these negative impacts are expected to increase, to which increased research investments and awareness of all stakeholders are suggested, so that the said impacts would be addressed properly.

Given the preceding information, climate change could expose farmers to higher levels of risks where farmers are likely to face additional costs of capital adjustment (Kingwell, 2006 and Quiroga Gomez and Iglesias, 2005). Investing in long-lived climate-dependent agricultural assets such as those mentioned earlier will become more difficult, and investing in ecological assets in rural regions, especially where these assets may become stranded by climate change, will be also increasingly constrained (Kingwell, 2006). This was corroborated years ago in the research of Nelson et al. (2009), wherein additional price increases are among the impacts expected.

However, in understanding climate change, uncertainty is crucial but remains poorly understood. Modeling of low-probability catastrophic outcomes likewise remains very limited (Quiggin, 2008). Nam Tran et al. (2012) endeavored on the estimation of risks associated with price changes as influenced by climate change. Their research considered how a rational, forward-looking and competitive commodity market would account for the anticipated changes and thereby influence the time path of storage, prices, price volatility, and social welfare. Results of which showed that price volatility would increase fivefold and welfare loss would be equivalent to food for 180 to 200 million people in the world annually by 2020.

Any of the impacts of climate change has the potential of increasing price risk levels because of the incidence of market turbulence. Fluctuations in commodity prices are inevitable under climate change because uncertainties are usually increased, which are considered largely critical in market analysis. They obviously affect the decisions made by producers and consumers. They play a crucial role in commodity-related investments, project appraisals, and project planning. In addition, they also reflect and influence the general economic activity. The ability to forecast accurately the prices of commodities significantly matters in policy and business circles (Bernard et. al, 2006). Volatile movements in prices are associated with risks and uncertainties (Balanay, 2011). Highly volatile prices are known to be a deterrent to agricultural productivity, because they tend to intensify inflationary pressures. Such prices can increase the uncertainty faced by farmers and agribusiness firms, which affect farmers' investment decisions and have serious ramifications on the growing farm debt, decreasing farm income and productivity (Kargbo, 2005). Thus, price volatility translates to significant price risks that complicate already-established agribusiness practices (Rezitis and Stavropoulos, 2009 and Mark et. al, 2008 as cited by Karali and Power, 2009).

The factors of volatility are many and they are usually those that contain some elements of surprise. As observed, supply in general can be substantially volatile; more so with situations involving unusually adverse climatic or pest conditions because of large but short-lived supply shocks created consequently (Ramirez, 2009). In agriculture, various models have been used to estimate and understand the behavior of price volatility. Threshold autoregressive (TAR) models whose specification allowed for two different autocorrelations regimes to apply depending on the value of the error (et) during the previous time period was used by Ramirez in 2009 to enhance the understanding of the dynamics and provide for a better forecasting of US soybeans and Brazilian coffee prices. His study further provided useful insights on the markedly different dynamics of the upward versus the downward cycles exhibited by the prices of the said commodities.

From the reviewed literatures, this study takes note of the tendencies of climate change to escalate confounding elements in the behavior of economic variables, which are focused on poultry prices and supply in this study. The matter on risks that climate change can induce is worth verifying with the use of empirical models that have the capability of estimating these risks. Some researches have used autoregressive conditionally heteroscedastic (ARCH) approaches in studying price volatility that is known to induce price risk. In 1990 and 1998, Aradhyula and Holt (as cited by Rezitis and Stravropoulos, 2009) used the generalized version of ARCH or GARCH in studying price uncertainty and volatility in the broiler market. Their study generated the evidence of price volatility as an important risk factor in broiler supply.

Rezitis and Stavropoulos (2009) have used many variants of GARCH in their study on the Greek pork market, in which the quadratic NAGARCH model was found to capture better producer's price volatility that was an important risk factor of the supply response function of the same market. The findings of their study also showed that feed price was an important cost factor in Greek pork supply and that high uncertainty restricted the expansion of the Greek pork sector. Bekkerman and Pelletier (2009) used the multivariate GARCH in examining basis volatility, where in the study they found significant increase in basis volatility in some corn and soybean markets after 2006. For the case of poultry in Northern Mindanao, Philippines, ARCH is likewise considered a good approach to take for the estimation of risk associated with volatile factors and the extension of analysis to supply response in order to understand producer's behavior towards the detected patterns of volatility in the market of poultry in the area.

Research Methodology

Quarterly and monthly time series data on poultry supply and prices, prices of other agricultural commodities such as pork, beef, rice and corn, consumer price indices (CPIs), and climate variables from 1994 to 2011 were used in the empirical analysis of producers' behavior towards climate and price risks in Northern Mindanao, Philippines. The data on poultry supply and prices and on the prices of the other agricultural commodities were obtained from the Bureau of Agricultural Statistics (BAS) through the Countrystat website, while the consumer price indices were downloaded from the online information facility of the National Statistical Coordination Board (NSCB). The climate data, on the other hand, consist of mean temperature and rainfall amount, which were obtained from the Philippine Atmospheric, Geophysical and Astronomical Service Administration (PAGASA) of the Department of Science and Technology (DOST). CPIs were used to deflate the prices in the models for supply response analysis and producer's behavior towards risks to purge inflationary effects from the data series.

The estimation of price volatility and climate variability is done with the use of an autoregressive conditionally heteroscedastic (ARCH) model, which in the study of Rezitis and Stavropoulos (2009) was used to generate expected values and expected variances for supply response analysis under a Rational Expectations (RATEX) framework. Climate variability in this context is particularly represented by mean temperature and rainfall changes. The consequent supply response analysis in this study is then applied with error correction because of the possibility of cointegration, which has to be tested with Johansen test for cointegration. The model for supply response tries to predict the behavior of the commodity producers towards price and climate-related uncertainties. The process of estimating price and climate risks is adopted from the research of Modelina et. al, (2003) as cited by Jordaan et al.(2007), wherein preceding the use of ARCH is the test for stationarity or unit root test through Augmented Dickey-Fuller (ADF) test. Below is the schematic diagram of the framework for the analysis (Figure 1).

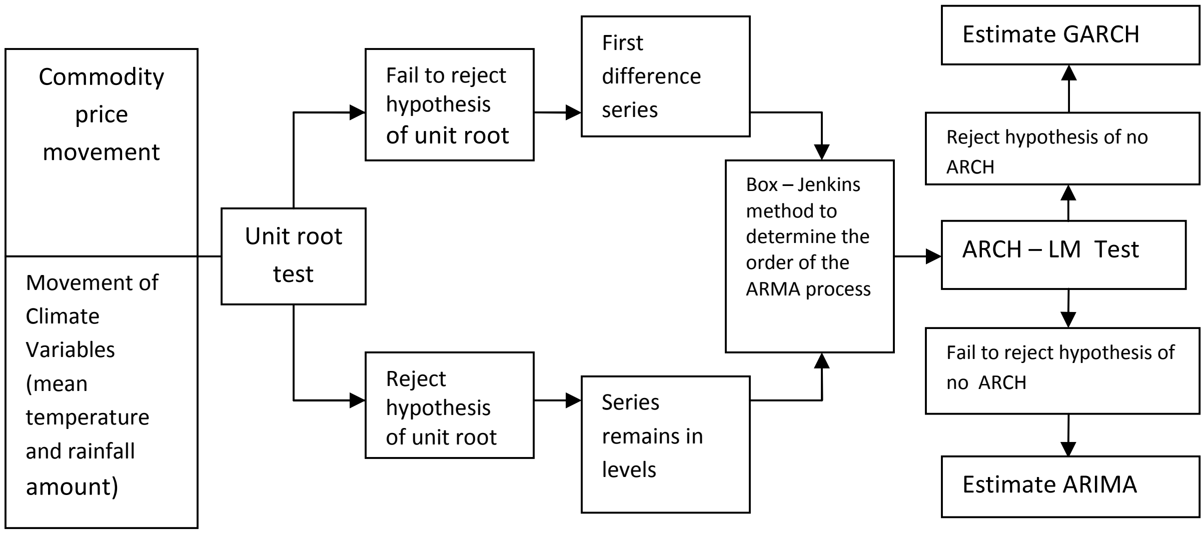

Figure 1: Framework for the Analysis of Volatile Behavior in the Poultry Price and Climate Data Series
Source: Modelina et al. (2003) as cited by Jordaan, Grove, Jooste and Alemu (2007)

Figure 1 shows the importance of warranting the use of ARCH in price, temperature and rainfall volatilities through ARCH-LM test. The ARCH-LM test would detect the presence of unpredictable behavior in the series, which is indicated by the significance of the ARCH-LM coefficient in the test results. In the event that unpredictable behavior is not detected through the test in the series, ARIMA would be used in the estimation, which would negate the presence of uncertain behavior that is eventually the source of risk in commodity markets.

The basic framework of analysis for price, temperature and rainfall volatilities in this study is patterned after the work of Rezitis and Stavropoulos (2009). ARCH as the main model of analysis is specified as follows:

(1)
$$P_t \mid \Omega_{t-1} = c_0 + \sum_{i=1}^{n} c_i P_{t-i} + \varepsilon_{2t}$$

(2)
$$h_t = b_0 + \sum_{i=1}^{q} b_{1i}\varepsilon_{2t-i}^2 + \sum_{i=1}^{p} b_{2i}h_{t-i}$$

$$\varepsilon_{2t} \mid \Omega_{t-1} \sim N(0, h_t)$$

Where: $b_0 > 0, b_{1i} \geq 0\ i = 1,...,q, b_{2i} \geq 0\ i = 1,..., p, \sum b_{1i} + \sum b_{2i} < 1$. The ARCH (Engle, 1982 as cited by Rezitis and Stavropoulos, 2009) makes the conditional variance h_t to depend on past volatility measured as a linear function of past errors, ε_{2t} while leaving unconditional variance constant. In Equation 1, ε_{2t} is a discrete time stochastic error, and Ω_{t-1} is the information set of all past states up to the time t – 1. In Equation 2 (GARCH conditional variance equation), h_t is the conditional variance specified as a linear function of p lagged squared residuals and its own q lagged conditional variances. The variance is expected to be positive, and so are the coefficients b_0, b_{1i} and b_{2i}. The stationarity also of the variance is preserved by the restriction $\sum b_{1i} + \sum b_{2i} < 1$. The predictions of P_t^e and h_t are to be generated by the ARCH/GARCH model, which could be used in estimating the supply response function (Rezitis and Stavropoulos, 2009). The deflated retail prices of poultry products would be evaluated with Equation 1 and the generated errors from Equation 1 would be autoregressively analyzed with Equation 2. The same analytical procedure would be used to analyze the behavior of temperature, rainfall and their changes over the period of 1994 to 2011 for inference about producer's behavior towards climate-induced risk in later supply response analysis.

The estimates of Equations 1 and 2 would generate the expected price levels and variances of price, temperature and rainfall, which are integrated in the supply response functions of the poultry products of Northern Mindanao, Philippines. The supply response analysis is undertaken with seemingly-unrelated regression (SUR) due to the simultaneous analysis of supply response of poultry products (dressed chicken and chicken eggs). The specification of the supply response for each poultry product in Northern Mindanao, Philippines is as follows:

$$QP_p = \sum_{i=1} a_i D_{it} + a_B TR_t + \beta_1 RV_t + \beta_2 TV_t + \beta_3 RP^e_t + \beta_4 RPV_t + \beta_5 BP_t + \beta_6 PP_t + \beta_7 P_t + \beta_8 RP_t + \beta_9 CP_t + \delta e_t + e_t$$

Where: QP_p is the production of a poultry product (dressed chicken or chicken egg) in metric tons at time period t; D_{it} is quarterly dummy variable (i = 1, 2, 3 and 4); TR_t is the trend component; RV_t is the expected variance and variability of rainfall at time t; TV_t is the expected variance and volatility of temperature at time t; RP_t^e is the expected real retail price of a poultry product (dressed chicken or chicken egg) at time t; RPV_t is the expected variance of the real retail price of a poultry product (dressed chicken or chicken egg) at time t; BP_t is the real retail price of beef at time t; PP_t is the real retail price of pork at time t; P_t is a real retail price of another poultry product (dressed chicken or chicken egg) at time t; RP_t is the real retail price of rice at time t; CP_t is the real price of corn at time t; e_t is the error term; and $a_i, a_B, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8, \beta_9, \delta$ are the regression coefficients in the model. Note that a weighted error is incorporated in the model to absorb the influence of cointegrating relationships that would be determined through the Johansen test for cointegration. Adjustment is necessary for cointegration to obtain robust estimates.

The same analytical process would be also used in determining the supply response of the other poultry product. Switching of places would transpire for dressed chicken and chicken eggs in the course of analysis since both are substitute protein sources for each other and likewise the products being studied. Thus, when dressed chicken's supply is analyzed, chicken egg prices are among the regressors and vice versa. RV_t, TV_t, RP_t^e and RPV_t are expected values estimated through ARCH using equations 1 and 2. The inclusion of beef and pork prices in the model represents the influence of the competing products and substitutes of poultry on its supply. The prices of rice in the model would generate the effect of the prices of a complementary good on the supply of poultry, while the prices of corn would pose the influence of an input on poultry supply. In the Philippines, corn is the most popular feed ingredient for commercial poultry and other meat production industries. The lag length in the autoregressive analysis is determined by Akaike information criterion (AIC).

Results and Discussion

Stationarity and Cointegration of the Price and Climate Data Series in Northern Mindanao

The presence of unit roots in the price and climate series was assessed through ADF test. In Table 1, the results show that at level form (L) the prices of rice, corn, rainfall amount and mean temperature are the only parameters that are stationary (no unit roots). Unit roots indicate non-stationary data; which purport the need of differencing when significant to obtain a white noise for robust analysis. The rest of the parameters have to be first-differenced to become stationary. Stationary data are important in ARCH and in supply response analysis to obtain reliable results.

Table 1: ADF Test results for stationarity of prices and climate variables

Variable	ADF Statistics *L*	*FD*
Real retail price of rice	-2.7**	-4.1***
Real retail price of corn	-2.7***	-8.3***
Real retail price of beef	-2	-8.8***
Real retail price of pork	-2	-6.1***
Real retail price of dressed chicken	-2	-9.7***
Real retail price of chicken egg	-2.2	-7.3***
Amount of rainfall	-3.1**	-11.4***
Mean temperature	-2.9**	-6.3***

Ho: There is a unit root. Ha: There is no unit root.
** significant at 5% level of confidence
*** significant at 1% level of confidence

In Table 2, dressed chicken and chicken eggs are found loaded with cointegrating relationships with the parameters considered in supply response analysis since the number of cointegrating vectors is more than 9. Therefore, the estimations for the said products have to be adjusted through an error correction factor, specifically in supply response analysis. Robust estimates can be obtained only when problems associated with cointegration are addressed. Cointegrating relationships exist when data series move with similar stochastic drifts; wherein dubious results are yielded when left uncorrected.

Table 2: Johansen Cointegration Test result for dressed chicken and chicken eggs

Commodity/ Lag Length	Hypothesized Number of CE(s)									
	k = 0	k ≤ 1	k ≤ 2	k ≤ 3	k ≤ 4	k ≤ 5	k ≤ 6	k ≤ 7	k ≤ 8	k ≤ 9
Dressed Chicken (1)	571.4***	442.6***	347.4***	273.3***	209.1***	153.5***	109.9***	76.2***	46.8***	18.3***
Chicken Eggs (1)	694.3***	433.9***	285.2***	188.1***	125.6***	70.6**	38.9	25.0	12.8	4.9**

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. ***, ** and * indicates that the null hypothesis is rejected at the 1%, 5% and 10% levels, respectively.

The lag length chosen by the AIC criteria is shown in parentheses after relevant poultry product.

Testing the Price and Climate Data with ARCH Effects

Table 3 shows the results of ARCH-LM test for the parameters involved in the supply response analysis of poultry in Northern Mindanao. The prices of rice and corn represent respectively the influence of a complement and an input in production; the prices of beef, pork and chicken eggs and dressed chicken represent the influence of substitute protein sources, and the rainfall and temperature the influence of climate in the production of poultry products. As shown, all parameters are highly significant in the test for ARCH effects, which indicate that their movements have unpredictable propensities. This finding also suggests that the use of ARCH for volatility analysis is warranted.

Price Volatility in Poultry

Price volatility is associated with the unpredictable behavior of prices or price uncertainty. Producers of commodities whose prices have significant price volatility often see themselves in a situation where planning milieus have confounding conditions. The presence of price risks (price volatility) is usually the reason why producers have the tendency to develop risk aversion.

In Northern Mindanao, dressed chicken and chicken eggs have significant price volatility. The prices of these products have a wide range of fluctuation, which make them difficult to predict.

As shown in Table 4, the prices of dressed chicken have highly significant ARCH/GARCH coefficients in the variance equation, which indicate substantial price volatility in the market for dressed chicken. Similar finding is observed in the chicken egg market (Table 5). ARCH/GARCH coefficients in the variance equation of chicken eggs are also highly significant; portending tremendous volatility in prices for the market of the said commodity.

The findings are disturbing for the market of these poultry products because the high level of unpredictability in prices may distress or dampen the interest of producers to innovate. Risk aversion is highly possible under the circumstances and can put market development at stake. However, the expected prices in the mean equations of price volatility estimations imply that current prices are influenced by their levels in the previous two months for both commodities (Tables 4 and 5).

Unpredictability of Climate

Based on the results in Tables 6 and 7, the effect of climate change augments the unpredictability of climatic behavior since the range within which rainfall and temperature can change has expanded. The ARCH/GARCH coefficients in the variance equations in the said tables are highly significant, which imply the risk associated with increased uncertainty brought about by the expanded range of change. Both climate factors are important in the care of poultry stocks for productivity. With the findings, it is possible that the climate variables can take extreme levels that are unsuitable for poultry enterprises. Particularly, unpredictable rainfall and temperature can induce mortality in poultry stocks and low product quality. In addition, rainfall is shown to be more random than temperature, because its expected level is just determined by its previous month's level compared to temperature where its current level is influenced by its levels in the past three months.

Table 3: Test Results for ARCH Effects of Price and Climate Variables, Northern Mindanao, Philippines, 1994-2011

Variable	ARCH-LM Statistics
F-Statistic	
Real retail price of dressed chicken	4267.9530***
Real retail price of chicken egg	883.1279***
Amount of rainfall	109.4960***
Mean temperature	12.5530***
Observed Square of Residual	
Real retail price of dressed chicken	248.731***
Real retail price of chicken egg	202.2374***
Amount of rainfall	77.8122***
Mean temperature	23.1594***

*** significant at 1% level of confidence

Table 4: Price Volatility of Dressed Chicken in Northern Mindanao, Philippines 1994-2011

Variables	Coefficient	Std. Error	z-Statistic	Prob.
		Mean Equation		
Constant	-0.0022	0.0022	-0.963	0.3356
Lagged real retail price of dressed chicken (Δ), t-1	0.3079	0.0805	3.8258	0.0001
Lagged real retail price of dressed chicken (Δ), t-2	-0.1909	0.0828	-2.3043	0.0212
		Variance Equation		
Constant	0.0007	0	15.2093	0.0000
ARCH(1)	0.1455	0.0457	3.1837	0.0015
GARCH(1)	0.3597	0.0607	5.9265	0.0000
GARCH(2)	-0.2168	0.0571	-3.8001	0.0001
Log Likelihood		565.5645		
N		261		

Table 5: Price Volatility of Chicken Eggs in Northern Mindanao, Philippines, 1994-2011

Variables	Coefficient	Std. Error	z-Statistic	Prob.
		Mean Equation		
Constant	-0.0011	0.0006	-1.8705	0.0614
Lagged real retail price of chicken egg (Δ), t-1	0.2514	0.0603	4.1686	0.0000
Lagged real retail price of chicken egg (Δ), t-2	-0.0194	0.0061	-3.1963	0.0014
		Variance Equation		
Constant	0	0	4.0953	0.0000
ARCH(1)	-0.0589	0.0158	-3.7203	0.0002
GARCH(1)	1.0278	0.0125	82.544	0.0000
Log Likelihood		553.723		
N		225		

Table 6: Unpredictability of rainfall in Northern Mindanao, Philippines, 1990-2011

Variables	Coefficient	Std. Error	z-Statistic	Prob.
		Mean Equation		
Constant	0.0072	0.0488	0.1469	0.8832
Lagged amount of rainfall (Δ), t-1	-0.3359	0.0591	-5.6849	0.0000
		Variance Equation		
Constant	1.0456	0.1704	6.1345	0.0000
ARCH(1)	0.085	0.0489	1.7385	0.0821
GARCH(1)	-0.7357	0.2292	-3.2094	0.0013
Log Likelihood	-308.6722			
N	262			

Table 7: Unpredictability of temperature in Northern Mindanao, Philippines, 1990-2011

Variables	Coefficient	Std. Error	z-Statistic	Prob.
		Mean Equation		
Constant	-0.0012	0.0012	-1.0288	0.3036
Lagged mean temperature (Δ), t-1	0.1249	0.0615	2.0313	0.0422
Lagged mean temperature (Δ), t-2	-0.1741	0.0569	-3.0605	0.0022
Lagged mean temperature (Δ), t-3	-0.2993	0.0559	-5.358	0.0000
		Variance Equation		
Constant	0.0009	0.0002	4.5429	0.0000
ARCH(1)	0.2159	0.1134	1.9036	0.0570
ARCH(2)	0.2463	0.1037	2.3758	0.0175
GARCH(1)	-1.2833	0.213	-6.0253	0.0000
GARCH(2)	-0.362	0.2135	-1.6954	0.0900
Log Likelihood		656.412		
N		260		

Supply Response of Dressed Chicken

The model for the supply response of dressed chicken takes an error correction factor to adjust for the presence of cointegration. Without this, the results of the estimation would be spurious because the true long-run relationships are obstructed with the high levels of feedback mechanisms. The supply response model has also a RATEX framework because of the inclusion of expected prices among the parameters. The purpose of including these expected prices is to determine the behavior of poultry producers towards forming price expectations, which is important in charting future actions towards market development.

As shown in Table 8, the parameters in the supply response model for dressed chicken consist of dressed chicken's expected prices, prices of its related goods, input price represented by corn's price, expected price variance as a measure of price volatility/risk, production timing, trend as proxy for technology, and error correction to represent the influence of feedback mechanisms. Shocks from climate change are represented in the model by rainfall variability and mean temperature variability, which correspond to their expected variances in ARCH.

The supply of dressed chicken in Northern Mindanao is affected significantly by production timing with production in Quarter 3 significantly lower than that of Quarter 1. The results show also that the producers recognize the pressures from risks associated with changing prices and temperature. This indicates that the two risks are affecting the producers' enterprises in proportions quite significant to their productivity and income. However, in terms of poultry producers' behavior towards these risks, they can be risk-takers towards price changes since the coefficient for the expected price variance is positive, but risk-averse towards temperature changes with the negative coefficient for the mean temperature variability. This implies that dressed chicken production may be reduced with risk aversion among the producers due to temperature changes. In fact, temperature variability (coefficient= -29.1987) is found stronger than price volatility (coefficient= 5.237), which suggests that producers are more affected by climate risk than price risk.

Supply Response of Chicken Eggs

Table 9 shows the results of the supply response analysis for chicken eggs. The findings are almost similar, except those corresponding to the expected price of chicken eggs and price volatility. The expected price of chicken eggs yields a significant coefficient, which is not the case in dressed chicken. This suggests that chicken egg producers form price expectations and tend to adjust chicken egg production by reducing it when prices are expected to rise. However, the expected price variance of chicken egg is insignificant, indicating that the market for the said commodity is not beset with price risks. Moreover, shocks are induced by temperature changes in the market for chicken eggs. From the coefficient of mean temperature in the model, chicken egg producers may become risk-averse with unpredictable changes in temperature. They may reduce chicken egg production when temperature changes become more erratic.

Table 8: Supply response estimates for dressed chicken in Northern Mindanao, Philippines. 1990-2011

Variables	Coefficient	Std. Error	t-statistic	Prob.
Constant	0.9406	0.56	1.6796	0.1031
Trend	0.0009	0.0011	0.8089	0.4247
Quarter 2	0.0658	0.0575	1.1438	0.2615
Quarter 3	-0.375	0.0566	-6.6268	0.0000
Quarter 4	0.0468	0.0515	0.9085	0.3706
Rainfall variability	-0.6073	0.6505	-0.9335	0.3578
Mean temperature variability	-29.1987	9.4306	-3.0962	0.0041
Lagged expected real retail price of dressed chicken (Δ)	0.4912	0.3986	1.2324	0.2271
Expected price variance of retail price of dressed chicken	5.237	2.169	2.4144	0.0219
Lagged real retail price of beef (Δ)	1.4725	1.266	1.1631	0.2536
Lagged real retail price of pork (Δ)	-0.8463	1.2027	-0.7036	0.4869
Lagged real retail price of chicken egg (Δ)	-0.8423	0.5593	-1.5059	0.1422
Lagged real retail price of rice (Δ)	-0.25	0.3495	-0.7152	0.4799
Lagged real retail price of corn (Δ)	-0.4601	0.2836	-1.6221	0.1149
Error-correction	-1.4731	0.1897	-7.7659	0.0000
R-squared	0.8878			
Durbin-Watson	2.0853			
N	46			

Conclusions and Recommendations

The results reveal that climate change has induced risk on the poultry market in Northern Mindanao with the unpredictability of temperature changes. Fluctuations in temperature can cause negative effects on the production of dressed chicken and chicken eggs. The tests also show volatility in prices or significant price risk, although not strong enough to depress poultry production, since the poultry producers are found risk-loving towards unpredictable price fluctuations. The significance of both risks in the market of poultry could present more confounding decision scenarios to poultry producers in Northern Mindanao. Thus, there is a need to raise concerns on climate change mitigation and adaptation as well as management of price risk in poultry. Interventions need to highlight monitoring and decision-support systems for market (prices, supply, demand, productivity indices, etc.) and climate indicators (temperature, rainfall, relative humidity, etc.) for forecasting and scenario analysis, genetic and/or breeding researches to improve poultry breeds, efficient storage and post-production systems, and insurance package for poultry producers to increase their market confidence. Further studies are recommended as well for the poultry industry in Northern Mindanao to succeed in sustaining its development.

Table 9: Supply Response Estimates for Chicken Eggs in Northern Mindanao, Philippines. 1990-2011

Variables	Coefficient	Std. Error	t-statistic	Prob.
Constant	0.9469	0.5888	1.6082	0.1179
Trend	0.001	0.0021	0.4893	0.6281
Quarter 2	0.0607	0.0582	1.0443	0.3044
Quarter 3	-0.3877	0.061	-6.3563	0.0000
Quarter 4	0.0352	0.0508	0.6926	0.4937
Rainfall variability	-0.6332	0.6715	-0.9429	0.3530
Mean temperature variability	-22.3997	10.4731	-2.1388	0.0404
Lagged expected real retail price of chicken egg (Δ)	-1.0159	0.5539	-1.8342	0.0762
Expected price variance of retail price of chicken egg	2.301	5.6526	0.4071	0.6868
Lagged real retail price of beef (Δ)	1.2896	1.3634	0.9459	0.3515
Lagged real retail price of pork (Δ)	-0.802	1.3226	-0.6064	0.5487
Lagged real retail price of dressed chicken (Δ)	-0.0041	0.3859	-0.0107	0.9915
Lagged real retail price of rice (Δ)	-0.4008	0.3789	-1.0577	0.2984
Lagged real retail price of corn (Δ)	-0.2108	0.2903	-0.7262	0.4732
Error-correction	-1.4732	0.1916	-7.6906	0.0000
R-squared	0.8726			
Durbin-Watson	1.8583			
N	46			

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