Modelling price expectation and volatility effects on producer behaviour: A case of Namibian Beef market

Abstract

The objective of this paper is to characterize beef producers' price expectation and investigate price volatility response in a rational expectation context for aggregate producers' supply response in the Namibian beef market using EGARCH (1, 1) model framework to monthly data ranging from January 2000 to December 2013. The study found that price uncertainty has strong influence in the beef market. Further investigation into producer price elasticity response shows that producers respond more strongly to price changes in the long-run than in the short-run. The findings also show that the expected price volatility has a negative and statistical significant relationship with beef supply, such that an increase in price volatility by one percent decreases beef supply by 0.05%. Other result for price volatility shows that there is a negative and significant asymmetric price effect. This means that a negative shock in price causes more volatility than a positive shock of the same magnitude.

Key words: Price expectation, volatility, asymmetric, elasticity, conditional variance.

JEL classification: C5, D2, Q1

Introduction

Agricultural productivity is highly risky, volatile and unpredictable. There is risk in production because prices are typically volatile, even more volatile than in other sectors (Holt and Moschini, 1992). This is characteristically so because of perishability in produce, lag and seasonality in production, consequently, resulting in inelastic supply constraint (Just, 1974; Holt and Aradhyula, 1990, 1998; Holt and Moschini, 1992; Rezitis and Stavropoulos 2009, 2012). This is why price volatility is regarded as an important risk factor in agricultural food supply.

The question is how do producers mitigate these constraints? What attitude do they develop towards risk - averse, seeking or neutral? No matter the position they adopt, studies have shown that their behaviour is significantly affected by price volatility (Aradhyula and Holt, 1989; Holt and Aradhyula, 1990; Holt and Moschini, 1992; Rezitis and Stavropoulos, 2008, 2009, 2012). According to these studies, price fluctuation translates into a significant price risk as such; an increase in price volatility implies higher uncertainty about future prices, a fact that affects producers' welfare. Due to the impact of commodity price volatility on general economic activity, an important concern for producers, policymakers and strategic analysts is to predict the impact of current and future changes in prices on production decision. This concern is based on the notion that producers and market agents are rational in the sense that their expectations of price levels and volatility reflect some form of adaptive expectation; that at any time, their expectation of the distribution of future prices is a function of past realisations of prices (Nerlove, 1956; Nerlove and Bachman, 1960). As a result, supply response is based on the hypothesis that quantity produced depends on input prices and producers' expectation of output price. This notion has been widely investigated with mixed results. For example, analyst such as Antonovitz and Green (1990), showed that producers have negative expectations drawn from past sales which led them to conclude that expectations are heterogeneous. This implies that, while some studies find positive expectations in some sectors, it could be negative in others sectors or countries.

Research Objective

Therefore, the objective of this paper is to characterize price expectation and investigate price volatility response in a rational expectation context for aggregate producers' supply response in the Namibian beef market. Studies on producer expectation abound in the literature but no known study has been carried out in the Namibia beef sector. A study by Hangura, Teweldemedhin and Groenewald (2011) measured supply response at farm level in four communities ignoring the effects of future price expectation on the supply response of the farmers. This study incorporates future price expectation in the aggregate supply response model and as well explore price volatility.

Problem statement

A major concern in the literature about modelling price expectation and volatility is selecting appropriate modelling framework that will properly characterize the time-varying nature of unobserved expectations and conditional variance. Analysts have used several methods for this purpose. For example, Just (1976), applied adaptive expectation model to specify risk as a weighted moving average of the squared deviations between lagged expectation and realized outcome. Other methods such as time series model, were used by Roe and Antonovitz (1984) and Antonovitz and Green (1990). The problem is that, the conditional and unconditional variances associated with these models are time-invariant. Engle (1982) proposed autoregressive conditional heteroscedasticity (ARCH) model which can be used to model time-varying conditional variance. Bollerslev (1986) generalised the ARCH model now called GARCH by allowing the conditional variance of the error process to be an autoregressive integrated moving average (ARIMA) process. In the GARCH model, the conditional variance depends not only on the past values of the time series, but also on a moving average of the past conditional variance. Several authors have evaluated the effects of price uncertainty in agricultural supply response using the GARCH and multivariate GARCH models (Aradhyula and Holt, 1989; Holt and Aradhyula, 1990; Holt and Moschini, 1992; Rezitis and Stavropoulos, 2008, 2009; 2012). Although the GARCH model has been widely used to model changing conditional variance, it has some limitations that weaken its theoretical appeal and empirical success (Nelson, 1991).

According to Nelson (1991), the GARCH model posits positive autocorrelation in the conditional variance (i.e. large (small) changes in the conditional variance are followed by large (small) changes in either sign) and ignores the fact that the conditional variance may be negatively correlated with future changes in prices or stock volatility, which implies that volatility is measured only by the magnitude and not the sign of the conditional variance. The GARCH model imposes non-negativity constraints on the parameters of the model to avoid the conditional variance being negative. The implication of this assumption is that the one-period-ahead-forecast conditional error variance will always increase if the squared standardised residual increases. This assumption does not allow for a situation where, due to random oscillatory movements, the conditional error variance could be negative.

To increase computational simplicity and empirical success in modelling conditional variance, Nelson (1991) proposed a model called the exponential GARCH (EGARCH) model which possesses features that are more attractive than those of the GARCH models. To ensure that the conditional variance remains nonnegative, it uses the log linear form of the conditional variance (at a given set of time) and the lagged standardised residuals, i.e. the log of the variance is conditional on its own past values, as well as a function of the standardised residual. This study uses EGARCH model to characterize the time-varying conditional mean and variance of expected price and volatility in an aggregate supply equation. Unlike GARCH, the possibility of asymmetric price volatility effects is determined using maximum likelihood estimators in an EGARCH model. Asymmetric price volatility is observed when there is different volatility between a decrease and an increase in price of the same magnitude. Positive asymmetry suggests that beef producers react faster to price increases than decreases of the same magnitude – an indication of market power. Negative asymmetric price volatility suggests that beef producer have weak market position and cannot increase price to exploit the market, but can decrease price to stay in it. Like EGARCH, there are other members of the GARCH family that can be used to model asymmetric conditional variance, examples are the asymmetric GARCH model called AGARCH (Engle, 1990), the Non-linear asymmetric GARCH (NAGARCH), Quadratic asymmetric GARCH (QGARH), Threshold asymmetric GARCH developed by Glosten, Jagannathan and Runkle (1993) etc, nonetheless, EGARCH model is chosen because of its computational simplicity and ease of interpretation.

The rest of the paper is organized as follows: First, the Namibian beef industry is briefly reviewed. The review highlights the structure and the importance of the sub-sector. Second, the method used in the study is described, followed by the description of the data and the model specification. Empirical results are then presented and lastly closing remarks are given in the concluding section.

The Namibian Beef market

Namibia is an arid to semi-arid country with limited rainfall. Rainfall is low and highly variable with sporadic drought occurrences. The combination of low average annual rainfall and high rainfall variability limit agriculture in Namibia to extensive livestock farming. Nevertheless, large livestock production occurs on the natural rangelands. Beef cattle production predominates in the Northern part of the country where average annual rainfall is higher compared to small stock livestock predominantly produced in the central and the drier southern Namibia. The veterinary cordon fence (VCF) divides the North and southern Namibia. The Northern cordon fence has history of disease outbreaks, thus animal sale from this region require quarantine and strict certification conditions compared to the less-restricted southern part of the cordon fence.

Livestock production is dual, with thriving commercial sector and a resource poor communal husbandry. Forty four percent of all cattle in the country are found in the Northern Communal Areas, while more than 60% are found in the communal areas (south included). This is on only 48% of the available agricultural land, while just 40% of all cattle are found in the commercial area (53% of the available agricultural land).

The Namibian agricultural sector only contributed 4.1 % to GDP in 2012, of which the livestock contributed 2.3 % (Namibian Statistical Agency, 2012). The red meat sub-sector contributes more than 80% to the total contribution in the livestock sector, making it an import sub-sector. Beef cattle production is the dominant agricultural sector, constituting approximately 85% of agricultural incomes and on average 10% of gross national product (Kruger and Imbuwa, 2008:6). The number of beef cattle sold during the third quarter of 2014 was 163753 units (including the Northern Communal Area (NCA) and butchers), a decline of about 53% from 348621 livestock marketed in 2013 (Meat board 2014:4).

Cattle farming occur exclusively on natural grazing, supplemented with mineral licks to which a limited amount of grain is added. Feedlots are generally not viable in Namibia, due to the small scale and unreliability of grain production and high transportation costs associated with grain imports. The small internal market dictates that Namibia has to export most of its beef. Until recently, Namibia exported about 70-80% of its total livestock production on-hoof, mainly to South Africa. The country is a net exporter of livestock with major export destination being South Africa, Angola, European Union and Norway.

Methodology

The empirical model specify beef equation as a function of expected price and its conditional variance and a vector of independent variables consisting of inputs prices, time; which stands for technology, and rain as additional factors of production. The equation is represented as follows

$$y_t = a_o + a_1 P_t^e + a_2 h_t + a_3 x_{1t} + \varepsilon_{it} \quad (1)$$

Where, y_t is the beef supply, P_t^e is the expected price, h_t is the expected price variance which measures volatility, $x_{1t}^{'}$ is a vector of independent variables and ε_{1t} is a mean zero normally distributed error term with variance σ. The EGARCH (p,q) is used to generate the variables P_t^e and h_t. The price expectation is generated from

$$P_t \left| \Omega_{t-1} = c_o + \sum_{i=1}^{n} c_i P_{t-1} + \varepsilon_{2t} \right. \quad (2)$$

The variance equation is given as

$$\log h_t^2 = \exp\left[\psi + \sum_{i=1}^{q} a_i \, g(z_{i-1}) + \sum_{k=1}^{p} b_k \log(h_t^2) \right] \quad (3)$$

Where $\{\psi_t\}_{t=-\infty,+\infty}$ and $(a_t)_{t=1,\infty}$ are real positive or negative and non-stochastic (stationary) scalar sequence and z is the standardized residuals. The EGARCH model considers asymmetric relationships between price and volatility changes and thus measures both the magnitude and sign of the standardized residuals. In the model, the coefficients are allowed to be negative or positive, which implies that the response to price changes could be asymmetrically positive or negative, thus measuring the asymmetric impact of shocks as follows:

$$g(z_t) \equiv \theta z_t + \gamma\left[|z_t| - E|Z_t| \right] \quad (4)$$

If γ is insignificant, positive and negative shock have same effect on volatility. If γ is < 0, negative shock increases volatility more than positive shock of the same magnitude.

The persistence of shock is measured by the absolute value of b_k.In equation (3), the regularity condition in the EGARCH model requires that $0 < b_k < 1$. If the unconditional variance is finite, the absolute value of $b_k < 1$. If the coefficient is significant, there is a significant evidence of persistence of shock. The smaller the absolute value of b_k the less persistent volatility will be after a shock. If the value of b_k approximates unity, the shock will persist into the future. This implies the presence of long memory and indicates that the fluctuations in the market will remain for a long period of time (permanent).

The relative marginal risk premium

If the point elasticity of supply is known, and the supply elasticity with respect to the price variance is known, the relative marginal risk premium for a producer can be derived. Relative marginal risk premium is the ratio of the variance and price elasticity of supply. Holt and Moschini (1992) developed an indirect cost function model to show how it can be calculated. The model posits producers as having a constant absolute risk aversion utility function, with price risk being conditionally normal. Expected utility can be maximized as a linear mean-variance criterion.

Assuming the farmer's expected utility function is given as

$$\underset{(y)}{Max}\left[\bar{p}y - C(y,w) - \tfrac{1}{2}\lambda y^2 \sigma^2\right], \qquad (5)$$

Where y is the output; $(\bar{p}, \sigma^2)$ are the *ex-ante* mean and variance of price; $C(y,w)$ is the indirect cost function, w is the input prices; and λ is the constant coefficient of absolute risk aversion. The first order condition for maximization is given as

$$\bar{p} - C_y(y, \underline{w}) - \lambda y \sigma^2 = 0. \qquad (6)$$

Where marginal cost $C_y < \bar{p}$ and $\lambda y \sigma^2$ is the marginal risk premium. Given the optimal supply response as

$$y* = y(\bar{p}, \underline{w}, \sigma^2), \qquad (7)$$

γ is the risk aversion parameter. If say, $\eta_p \equiv (\partial y / \partial \bar{p})(\bar{p} / y)$, and $\eta_\sigma \equiv (\partial y / \partial \sigma^2)/(\sigma^2 / y)$, where $\eta_{\bar{p}}$ is the point price elasticity of supply and η_σ is the supply elasticity with respect to price variance, differentiating the two functions gives the marginal risk premium as a proportion of expected price – the percentage departure from the marginal cost pricing.

$$-\frac{\eta_\sigma}{\eta_p} = \frac{\lambda y \sigma^2}{\bar{p}} \qquad (8)$$

This function was used to estimate the response of price risk in the beef market.

Data and model specification

The data used in this study are the monthly beef supply, producer price of beef, maize spot price and rainfall from 2000 to 2013. Beef supply data was obtained from the meat board of

Namibia. It consists of the total number of beef marketed in export abattoirs, butcheries, and the numbers sold abroad. The producer price was also sourced from the meat board. It is the average carcass producer price measured in Namibian dollar per kilogramme (N$/kg). There was a huge constraint in getting input data; as a result, maize spot price was used as a proxy for input prices. Maize price was used because maize is a major component of animal feed which constitutes a large part of input cost. The South African futures exchange (SAFEX) yellow maize spot price was used. The spot price was approximated to the Namibian price by multiplying the spot price with the distance between Windhoek and Johannesburg. Rainfall is an import parameter in supply response. Monthly rainfall data was sourced from the Namibian Meteorological Services. All the variables are log transformed, and all prices are deflated with consumer price index obtained from the Namibian Statistical Agency.

The empirical model is based on two production-price models representing the producer-price structure of the Namibian beef market. The assumptions are that: (i) beef market is competitive; (ii) prices are determined by the forces of demand and supply, (iii) producers form expectations about endogenous variables in a manner consistent with rational expectation hypothesis, (iv) producers are risk averse, and that, (v) beef price is a major source of uncertainty in the beef market. Considering the above assumptions, price expectation, price volatility and the level of risk (averse, neutral, or seeking) is investigated. Following the supply model (1), the beef supply response equation is specified as:

$$QSB = a_0 \sum_{i=1}^{12} a_{it} D_{it} + a_{it} DTm_T + a_{10} EPPB_t + a_{11} PPBV_t + a_{12} Ymaz_{t-8} + a_{19} QSB_{t-1}$$
$$+ a_{20} QSB_{t-12} + a_{31} Rn_{t-1} + a_{32} Tm_T + \varepsilon_{1t} \qquad (9)$$

Where QSB_t is the quantity of beef supplied to the market in period t. Seasonal dummies D_{it} are used to account for seasonality in beef production. Interaction dummies DTm_T are included to cater for the interaction between seasons and time. In other words, the effect of technology is assumed to respond to seasonal production. The EPPB and PPBV are the expected producer price and the producer price volatility respectively. They are important risk factors and are included to capture farmer's price expectations and volatility. As mentioned prior, input cost is proxied by yellow maize price, $Ymaz_t$ which is a major component of beef input price. Production lags are also included; this is represented by QSB_{t-1} and QSB_{t-12}, one and twelve lag structures were used to take care of the lags in beef production because producers may not be able to adjust production to the desired level during the year. Lastly, one period lag of rain was included to represent the impact of rain as a factor of production in the beef industry.

Price and conditional variance equation

The autoregressive order of the producer price shows that it is adequately represented by a third order autoregressive lag. The real producer price equation is given by

$$PPB_t = \alpha_0 + \sum_{i=1}^{3} \alpha_i PPB_{t-i} + Tm_T + \varepsilon_{2t} \qquad (10)$$

Where PPB_t is the real producer price of beef in time t, Tm_T is as defined in equation (9), PPB_{t-i} is the real producer price at time $t-1$, where $i = 1,.....3$ The lag structure was determined using general–specific method to be 3, therefore three lags were used in the estimation.

The conditional variance model is given by equation (3). The EGARCH orders were selected by minimizing Akaike information criteria (AIC) and Schwarz-Bayesian Information Criteria (SBIC). EGARCH (1, 1) order was the most appropriate. The producer-price models of equation (9) and (10) were modelled simultaneously in an EGARCH model using Maximum likelihood estimation procedure. The expected price $EPPB_t$ in equation (9) was obtained from equation (10). This represents the future expectation of farmers which they formed using producer price at $t-1$. The conditional variance term in equation (9) is obtained from the conditional variance component of the EGARCH (1, 1) model. Additional cross-equation restrictions are imposed by the EGARCH (1, 1) model. The assumptions are that errors are normally distributed and the Marquardt logarithm is used to obtain the maximum likelihood estimates of the system represented by the supply equation (9) and price equation (10).

Empirical results

Unit root test was performed to determine the time series property of the variables. This was conducted using three different unit root tests; the augment Dickey-Fuller, Kwiatkowski-Phillips-Schmidt-Shin, and Elliott-Rothenberg-Stock DF-GLS test. Intercept and trend components were included in the tests. The tests show that the producer and maize prices are non-stationary whereas the quantity supplied of beef is stationary in levels (Table 1). The results justifies the inclusion of intercept and time trend in the models.

Table 1. Results of Unit root test*

	ADF		KPSS		DF-GLS	
	Null: Unit root present		Null: Stationary		Null: Unit Root present	
Variable	Test-Stat	Critical value	Test-Stat	Critical value	Test-Stat	Critical value
PPB	-2.7051	-4.0135	5.7103	0.739	-2.8048	-3.4996
QSB	-4.0362	-3.4731	0.23	0.739	-0.6626	-2.5801
Ymaz	-1.7345	-4.0139	0.7805	0.739	-1.8709	-3.4996

*Test were conducted with both intercept and time trend variables. ADF stands for Augmented Dickey-Fuller test, KPSS stands for Kwiatkowski-Phillips-Schmidt-Shin test, and DF-GLS stands for Elliott-Rothenberg-Stock DF-GLS test.

The empirical results are presented in Table 2. The results show that the short-run supply price elasticity (EPPB) is positive and significant (Table 2, Row.11:Col.2). This result indicates that a one percent increase in the producers' expectation about future beef price changes induces beef producers to sell 0.27% of their animals instead keeping stock. This could be because producers perceive expected prices as transitory, if they do not sell and perhaps hope to increase future production; it is uncertain what the price will be, that induces them to sell in the short-run.

Table 2. Maximum Likelihood Estimation of Beef Supply Response

	Supply Equation				
	Variables	**Coefficient**	**Standard. Error**	**z-Statistic**	**Probability**
S/N	**1**	**2**	**3**	**4**	**5**
1	Constant	6.9129	0.9641	7.1707	0.0000*
2	Dum2	-0.3989	0.1028	-3.8789	0.0001*
3	Dum10	-0.3370	0.0786	-4.2850	0.0000*
4	Dum11	-0.5274	0.0870	-6.0599	0.0000*
5	Dum12	-0.9302	0.1807	-5.1483	0.0000*
6	Dum2T	0.0026	0.0010	2.7648	0.0057*
7	Dum3T	0.0022	0.0005	4.2909	0.0000*
8	Dum10T	0.0023	0.0010	2.3353	0.0195**
9	Dum11T	0.0031	0.0010	3.2023	0.0014*
10	Dum12T	0.0033	0.0018	1.8733	0.0610***
11	EPPB	0.2722	0.1079	2.5226	0.0116**
12	PPBV	-0.0479	0.0270	-1.7733	0.0762***
13	Ymaz	-0.0151	0.1454	-0.1569	0.4971
14	QSB(t-1)	0.5414	0.0547	9.8985	0.0000*
15	QSB(t-12)	-0.0920	0.0562	-1.6356	0.1019
16	RAIN(t-1)	-0.0001	0.0001	-1.9407	0.0523***
17	TIME(t-1)	-0.0019	0.0007	-2.5204	0.0117**
18	R^2	0.73			
19	Log Likelihood	73.1026			
20	Durbin Watson	2.2815			
21	No. Observations	153			

Note: * = Significant at 1%, ** = Significant at 5%, *** = Significant at 10%

Table 4 shows the calculated long-run price elasticity of beef supply is 1.5596. The result shows that the supply of beef is highly elastic in the long-run. In the long-run, producers react strongly to price changes than in the short-run. The estimated beef short-run price volatility is -0.0479. It is significant and has the expected negative sign, indicating that price volatility has a significant negative effect on producer supply response. The calculated long-run price volatility is 0.0326. The result shows that price volatility in the long-run is less elastic than short-run volatility.

The positive sign indicates that producers in the long-run may either diversifies into other profitable venture or enters into risk management mechanism such as animal insurance or commodity exchange future and option market that may help reduce market risk.

The study also investigated the impact of feed cost on the producer supply response. The estimated coefficient for yellow maize price, $Ymaz$, is -0.0151. This result shows that there is a negative but insignificant relationship between producers' supply response and input cost. This means that, an increase in input cost may reduce the capacity of the producers to supply the optimal amount of beef given by equation (7).

Other important factors of production included in quantifying producers' response towards price expectation and volatility are the lag of rain and time. Time was used as a proxy for technology. It is expected that technological advancement will increase both efficiency and the level of beef production. The results show that, though time variable is statistically significant, the magnitude of the parameter estimate is small and it has an unexpected sign. The low magnitude and negative sign of the parameter suggests that available technology is not properly utilized. The low value of estimate could be due to lack of capacity (resources) for effective transfer of technology and low adoption rate which ultimately may result in a decline in the impact of technology. Improperly utilization may result in losses due to damages, for examples bruises occur to animals as they move in between kraals, loading facilities and feedlots, thus condemning the animals or reducing their market value. In addition, it may be that the available technologies are not suited to the producers, that is, not user friendly or even not affordable. In this instance, an increase in the supply of technology may result in a decline in the quantity of beef supplied.

The impact of rain on the supply response is negative and statistically significant (Table 2, Row 16: Col. 2). This relationship is as expected, because Namibia is an arid to semi-arid region with relatively low rainfall in drier southern regions and moderate to average rainfall in northern part of the country. There are periods of long dry spell resulting in loss of animals; the situation often degenerates into drought events that have occurred in many occasions. Because of this, beef producers tend to sell more animals during low rainfall for fear of losing them to drought. On the other hand, good rains increase the expectation of a good year, with producers withholding their animals to improve their weight, in anticipation to sell them during rainless periods or drought. This result is contrary to the findings of Gosalamang, Belete, Hlongwane and Masuku (2012) in the Botswanan beef market who found a negative and insignificant result with lagged price but calculated short-run elasticity of 1.511 with current price ignoring effects of expected price.

There is a mixed result for the different lags of the previous year's quantity of beef supplied. The estimate for the one-period lagged beef supply is positive and statistically significantly, indicating that increase in the previous year's supply results in a statistical significant increase in the current year's supply. The estimates for 12-period lags have a negative but insignificant relationship. On the average, the estimated coefficient for the previous periods supply is positive and statistically significant.

The result in Table 2 shows that the expected price volatility PPBV has a negative and statistical relationship with beef supply (Table 2: Row 12: Col.2). This result indicates that increase in volatility by one percent decreases beef supply by 0.05%. This is an indication that price volatility is an important risk factor for the beef industry. Therefore, price volatility should be considered when forming expectation about future production and prices. The historical path of the conditional volatility for beef is shown in figure 1. The figure shows that volatility peaks in February and April. The result is expected because cattle sales tends to increase during the festive month, December, in January sales decline, and pick up again from February, March and April when the obligation for school fees and other household debts such as vacation increases. The average and median values of beef volatility are calculated to be 1.1289 and 0.7479 respectively. These values however, are high, an indication of inability of the producers to control and stabilize prices in the beef market -- a sign of low market power. The response of producer to lagged supply is positive and significant (Table 2, Row 14: Col.2). Its coefficient is comparatively larger than the coefficient of price expectation, an indication that though producers respond to expected price changes, they are as well influenced by past supplies. All seasonal and interaction dummies included in the supply equation are statistically significant, signifying the importance of seasons and its interaction with relevant factors that effects beef supply.

Table 3 panel B presents the results of the estimated coefficients of the conditional variance given by equation 3. The value of the volatility persistence parameter b is (0.6014). It is statistically significant at one percent. The magnitude of the parameter is high, an indication that price volatility in the beef market is persistent. If volatility is persistent, any shock to conditional variance takes long time to be eliminated. The asymmetric parameter γ is negative and statistically significant (Table 3: Row 9: Col. 2). This implies that there is a negative and significant asymmetric price effect. This signifies that, a negative shock in price causes more volatility than a positive shock of the same magnitude. The result shows that, producers respond more intensely in case of a negative shock than a positive one. Example of a negative shock is the sudden rise in input cost that reduces market margin. This behaviour suggests that the beef producers have a weak market position. If they have strong position, they can manipulate the market by increasing price to adjust to the increased costs.

Table 3. Empirical Results from Price and Variance equations

	Panel A-Price equation				
	Variables	**Coefficients**	**Standard Error**	**Z-statistics**	**Probability-**
S/N	**1**	**2**	**3**	**4**	**5**
1	Constant	0.241689	0.016541	14.61128	0.0000*
2	PPB(t-1)	0.773471	0.035621	21.71366	0.0000*
3	PPB(t-3)	0.052022	0.029146	1.784896	0.0743***
4	TIME(t-1)	0.001356	8.18E-05	16.56547	0.0000*
5	**Panel B-Variance Equation**				
6	Col.[1]	Col.[2]	Col.[3]	Col.[4]	Col.[5]
7	Constant	-3.761682	0.375716	-10.01203	0.000*
8	a	2.597291	0.192132	13.51827	0.000*
9	γ	-0.729213	0.164152	-4.442308	0.000*
10	b	0.601408	0.060289	9.97545	0.000*

* = Significant at 1%, ** = Significant at 5%, *** = Significant at 10%

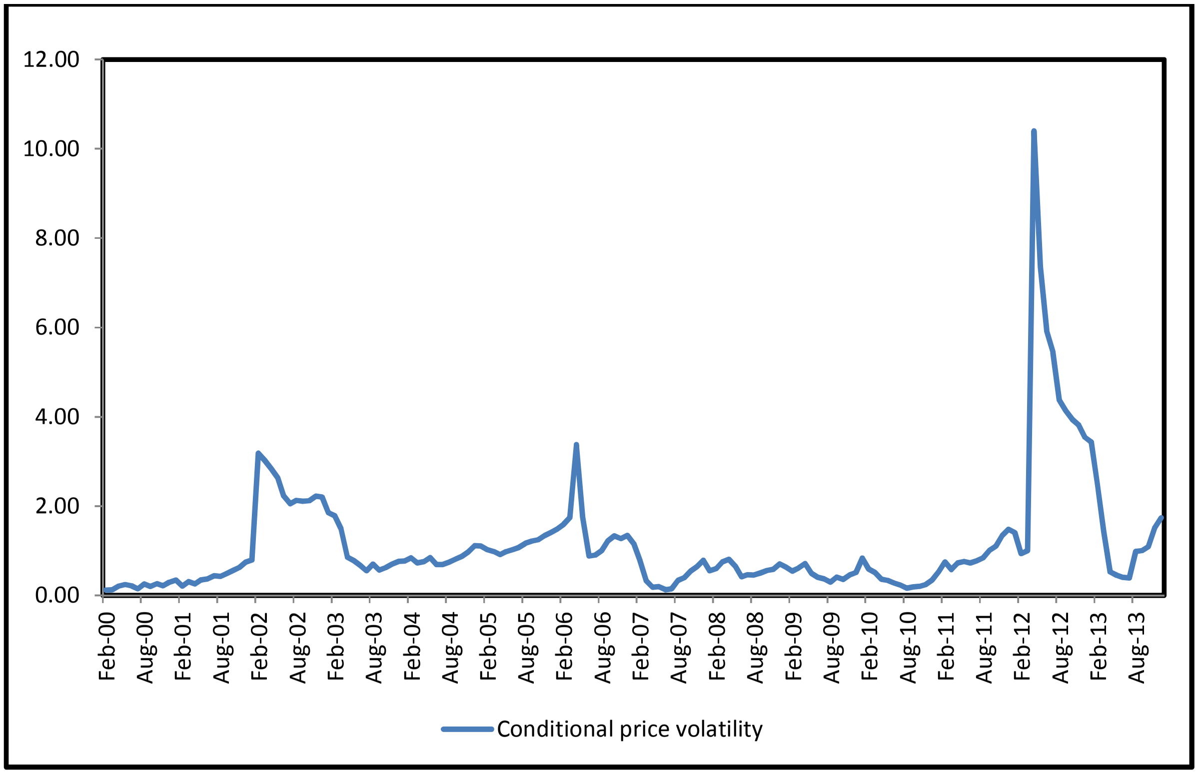
The relative marginal risk premium (RMRP) was calculated using equation 8. The RMRP is the negative of the ratio of variance and the price elasticities of supply (Holt and Moschini, 1992:3). It shows the marginal departure from marginal cost pricing. If RMRP is positive, producers are risk averse, if it is less than zero, producers are risk seeking, and if it is equal to zero, producers are risk neutral; a small and infinitesimal value of RMRP, that is, value equal to or close to zero is no different from risk neutrality. The estimated mean value of RMRP is 0.0221. It is positive, meaning producers are risk averse and it is close to zero, implying there is no strong departure from risk neutrality or marginal cost pricing. The calculated RMRP series ranges from a low of 0.2% to a high of 9.22% during the sample period, the average being 2.2%. Figure 2 shows the relative risk premium of beef producers. It can be noticed that RMRP is high during volatile months such as February to April and less during tranquil months.

The diagnostic tests for the EGARCH (1, 1) model adequacy are presented in appendix A. The results show that there is no serial residual correlation and heteroscedasticity in the residual of the EGARCH model. The null hypothesis of no serial residual correlation was not rejected at all 36 lags for both supply and price equation. The null for the ARCH test is that the residuals are homoscedastic. In the Lagrange Multiplier test shown in Appendix Table A1, the null was not rejected meaning that the residuals are homoscedastic.

Table 4 Elasticities of beef production 2000M1-2013M12

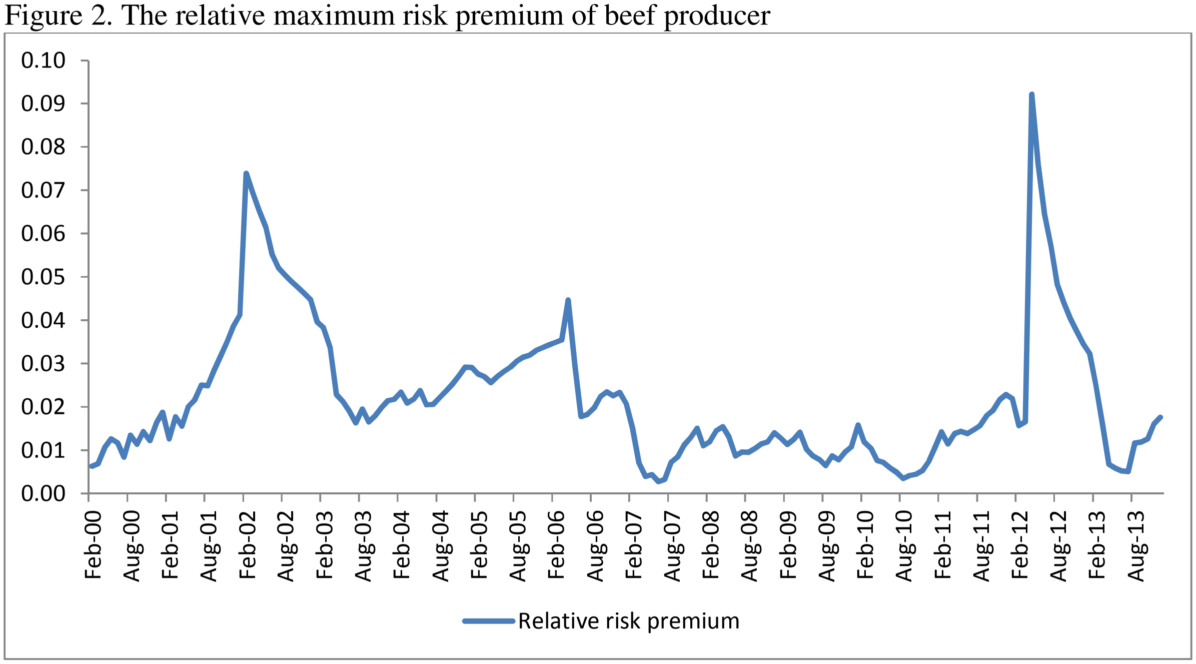
Model	Expected price of beef (EPPB)		Conditional variance (PPBV)	
	Short-run	Long-run	Short-run	Long-run
EGARCH estimates	0.2722	1.5596	-0.0479	0.0326

Figure 1. Conditional price volatility of Beef



Source: Author's computation

Figure 2. The relative maximum risk premium of beef producer



Source: Authors computation

Conclusion

This paper investigated the supply response for beef in Namibia. An EGARCH (1, 1) model was used to model beef producer's behaviour about expected price and expected price volatility. The study examined producers' reaction to changes in price expectation and volatility and found that producers exhibit rational type of behaviour in forming price expectation. Price volatility was found to have negative and significant effects on the beef production level, indicating that it is a major risk factor in beef production. The risk status of the producer was further invested to determine whether there is a departure from marginal cost pricing hypothesis. To achieve this, the relative marginal risk premium was calculated as a proportion of expected price. The results show that the marginal risk premium is positive and very low in value, indicating producers are risk averse, and they could as well be regarded as risk neutral because the value was not far from zero. In other words, the beef producers supply response to expected price and volatility changes does not departure from marginal cost pricing.

The results also show that the short-run price elasticity of beef supply is positive and inelastic. This result is consistent with results elsewhere (Rezitis and Stavropoulos, 2008; 2012). It indicates that in the short-run, price increases induces producer to supply more animals to the market. The inelastic short-run price elasticity is not surprising; given that cattle production cycle (from gestation to sale) is about 17 months, there is little time for adjustment and besides, market position and cost of adjustment contributes. The long-run price elasticity was found to be larger than short-run elasticity, an indication that in the long-run, producers improve their capacity to exploit the market; hence, supply becomes more elastic.

Other factors that influence beef supply includes, input price, rainfall and the effects of technology. Input price effects on beef supply were found to be negative, that is, if input price increases beef supply declines, but the effects was not statistically significant, indicating that though there is a negative result, cattle farming occur exclusively on natural grazing, with little supplementary feeding to which limited amount of grain is added. The study found that rainfall has a negative relationship with beef supply. This is because cattle owners sell their animals during dry periods in anticipation of drought, but keep them to gain weight for better price when it rains. Technological advancement has been found to enhance livestock production through improve health care and animal pre and post slaughter handling facilities. This study found that technology has a negative impact on beef cattle supply. This may have resulted from amongst others things, improper application or slow adoption rate of technology.

Examination of the effects of price volatility shows that beef producers have weak market position due to the presence of a negative asymmetric price effect. Producers seem to respond more intensely to negative price shock which increases price volatility than positive shock of the same magnitude.

In summary, the study found that price uncertainty has strong influence in the beef market, as a result, production may be constrained, and producers may be unlikely to expand to gain scale economies. Weak influence of technology in beef technology implies poor application, perhaps poor service delivery by the responsible stakeholders. Farmers training through extension services and other stakeholders should be improved to foster gains from technological innovation. Poor market infrastructure often results in asymmetric information;

improvement in the market infrastructure will encourage producers to make proper production and marketing decisions. The outcome of the study shows that it is important to adopt measures to manage price risk such as insurance or price hedge through commodity derivative market. To improve production and market performance, joint investment initiative such as private public partnership is encouraged.

Appendix A

Table A1.Test of correlation in the residual of EGARCH (1, 1) supply model*

Serial correlation Test-Supply Equation		Serial correlation Test-Price Equation	
Q-Stat	Probability	Q-Stat	Probability
0.169	0.681	1.3747	0.241
0.4144	0.813	1.4393	0.487
1.2269	0.747	1.533	0.675
1.5023	0.826	2.3547	0.671
1.6035	0.901	8.0766	0.152
2.6928	0.846	8.0802	0.232
3.9446	0.786	8.2881	0.308
4.7237	0.787	8.7982	0.36
5.2167	0.815	8.9326	0.444
5.3018	0.87	9.6613	0.471
5.3377	0.914	9.695	0.558
7.338	0.834	9.7354	0.639
9.298	0.75	9.8222	0.708
9.3746	0.806	9.8234	0.775
9.5882	0.845	10.401	0.794
9.7046	0.882	10.402	0.845
10.978	0.858	10.49	0.882
13.799	0.742	10.49	0.915
14.735	0.739	10.832	0.929
15.099	0.771	11.216	0.94
15.304	0.807	11.368	0.955
15.384	0.845	11.391	0.969
17.732	0.772	11.397	0.979
22.282	0.562	11.619	0.984
23.406	0.554	12.035	0.986
25.256	0.505	12.183	0.99
25.757	0.532	12.395	0.993
28.931	0.416	12.448	0.995
28.953	0.468	12.637	0.996
31.898	0.372	13.445	0.996
32.278	0.403	13.476	0.997
32.515	0.441	13.478	0.998
33.852	0.426	13.508	0.999
34.038	0.466	13.636	0.999
35.571	0.441	14.104	0.999
37.355	0.407	16.05	0.998
EGARCH Test**			
LM	0.1652 (0.6844)***	LM	1.4038 (0.2361)

*Null: There is no serial correlation in the residual of the EGARCH model. ** Null: There is no ARCH effect.

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