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# Modelling supply response and volatility of Swakara pelts in Namibia

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## Abstract

The karakul industry has been experiencing a continuous decline in the number of pelts supplied since the late 1970s. This decline is speculated to be a result of the anti-fur movement. Coincidently, throughout the years, the price of Karakul pelts has been seen to increase. This abnormal mismatch in supply and demand has challenged economic theory, which explains that price increases should increase supply. This paper uses time-series data from 1960 to 2019 to model supply response and volatility in the karakul industry. The dataset was tested for unit root, and an autoregressive distributed lag model was run to examine the extent to which the local production of Swakara pelts responds to the supply determinants. Pelt supply lagged one year; cost of production, average pelt producer price and average mutton producer price yield and the exchange rate have significant implications on the current pelt supply. However, the anti-fur movement's influence has a significant relationship. The results also indicated high volatility between all variables, with social awareness being the outlier. The global anti-fur movement has played a prominent role in Namibian farmers reducing their Karakul stock. Since 2012, nationally and globally, prices of all pelt and fur have continuously declined, which points to a "dying" industry. The survival of the Namibian pelt industry requires further research on the global demand and adjustments to legislation to support production incentives for farmer welfare.

**Keywords:** Karakul, production, trend, autoregressive distributed lag, and sustainability.

## Introduction

Namibia is among the top producers of karakul pelts, alongside Afghanistan and Central Asia, targeting major consumers mainly in Europe and the United States of America. Karakul is a broad-tailed sheep with long hair that produces intrinsic curl patterns. Although the overall trend of sheep production in the producing countries is increasing, Karakul production has declined since the early 1980s, while the price rapidly increases. This can be seen in local trends of Swakara demand and supply.

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The Namibian pelt situation cannot be assessed in isolation. Pelts functions within the fur markets to produce coats. The global retail value is estimated at around US$30 billion (Hansen, 2017), of which the Afghanistan Karakul contributes approximately US$8 million and the Namibian Swakara only US$1.5 million. The global volume of karakul production stands at approximately one-fifth to one-sixth of the total fur market volume. A karakul or Persian lamb coat sells for US$5,000 to US$12,000, depending on quality. A mink coat retails between US$10,000 to US$50,000, varying widely according to quality. The continuous decline in supply is assumed to result from fashion changes, production, and the infamous anti-fur movement, which has put a dent in the fur and pelt industry globally.

Furthermore, there exists a demand shift away from the traditional European markets toward the China market. Globally, the Copenhagen auction house traded almost 60% of furs in the early 2000s, declining turnover to 40% in the 2010s. This was taken up in China's fur trade, which increased from 5% to 35% in the same period (Hansen, 2017).

The anti-fur campaign resulted in different certification systems, such as the Scandinavian Saga furs (NOAH, 2015), to allow for social, economic and environmental responsibility. Namibia introduced a Code of Practice for Swakara producers. This adhered practice ensures the welfare of Swakara sheep. This strategy resulted in a doubling of prices obtained compared to the Afghanistan Karakul pelt (Ferdaws, 2015). The paper attempts to construct a supply response model for the Swakara sub-sector, which presents the supply responsiveness and its volatility to suggest specialised investments to benefit the Swakara sub-sector.

The Karakul industry was once a significant contributor to the gross domestic product in Namibia. It is assumed that a new equilibrium will be achieved by understanding the dynamics of the supply response of producers to price as well as the causes behind the pelt price volatility. Data indicate that between 1960 and 2019, there were fluctuations in the price of karakul pelts, although the overall price showed an upward trend. The supply of pelts continued to trend towards the ebb, namely from the mid-1970s till late. Because of the misreckoning of the volatility in prices, paired with structural changes in production, policy formulation was kept unchanged to prevent further welfare losses. Therefore, this study's premise is to provide empirical relationships between factors influencing karakul pelt production and price volatility in Namibia. To address the paper's objective, factors such as pelt supply, karakul flock, pelt producer prices, prices of mutton, cost of production and social awareness, and dollarized exchange rate were used to create the correct supply response model and describe producers' risks.

## Literature review on the dynamics of the Karakul industry

The Karakul sheep is the oldest domesticated sheep, introduced to Namibia in 1907 when the Germans imported twelve sheep consisting of two rams and ten ewes (Bravenboer, 2007). The breed can withstand Namibia's arid and semi-arid environmental conditions. As the industry grew, breeders experimented and improved the quality and condition of the karakul pelts. This resulted in the migration of farmers to the southern regions of Namibia. The Karakul industry peaked in the early 1970s before the industry experienced a decline in the demand for luxury goods. It is recorded by (The Karakul Board of Namibia, 2020) that in 1930, 91 000 pelts were produced. This figure increased to over five million in 1972 before the Anti-Fur campaign was assumed to have taken a toll on the industry. There were approximately 40 active breeders in Namibia, recorded in 2007 (The Namibian, 2007), and 14 breeders in South Africa (Visser, 2012), last recorded in 2012. The agricultural sector contributed 7.3% to the gross domestic product in 2019 (Namibia Statistics Agency, 2019), of which the Karakul sub-sector is part. Agriculture is considered the country's backbone because of the significant dependence of approximately 70% of the population on agriculture. Supply response models, therefore, allow the understanding of the responsiveness of agricultural commodities to price and non-price factors. It is argued among industry experts that there exists potential in the karakul industry, based on past contributions to the gross domestic product (Keet, 1949). Therefore, a well-developed supply response model for karakul pelts could explain producer behaviour and the effect of producer behaviour on total production. This model would thus provide a structural foundation for estimating response relationships between supply determinants.

Price volatility represents a significant risk factor for supply. This is because agricultural prices tend to be more volatile due to seasonality, inelastic demand, and production uncertainty, especially given Namibia's recurring drought. Price fluctuations create significant price risks, lowering farmers' output (De Pinto *et al*., 2019). Therefore, this paper further postulates that an increase in volatility creates higher uncertainty about future prices, affecting producer welfare.

The anti-fur campaign in the late 1970s has been seen to negatively affect the global production of pelts and fur, resulting in the decline of Karakul production in Namibia. The effect of such a campaign could have many stigmas attached to producers, of which the number of producers severely declined over the years from 751 in 1980 to 50 in 1996 (Bravenboer, 2007). Therefore, the null hypothesis is that social awareness and campaigns do not influence the supply decision of karakul pelts. Our alternative insinuates that social awareness and campaigns influence the supply decision of karakul, which impedes the production of pelts.

Figure 1 shows the trends of Namibian Karakul pelt production. This decline is assumed to result from the Anti-Fur Movement, which gained popularity in the 1980s but originally became active in the late 1970s. The almost six decades of data is essential to present trends required for producers' decisions. Long-run relationships can indicate the profitability of a market where firms are likely to enter if the market price is high enough to result in a positive profit or leave the market should market prices be below. Additionally, a long-run relationship between supply determinants can have real effects on the economy and can thus be used as proper tools for policy formulation within the Karakul industry.

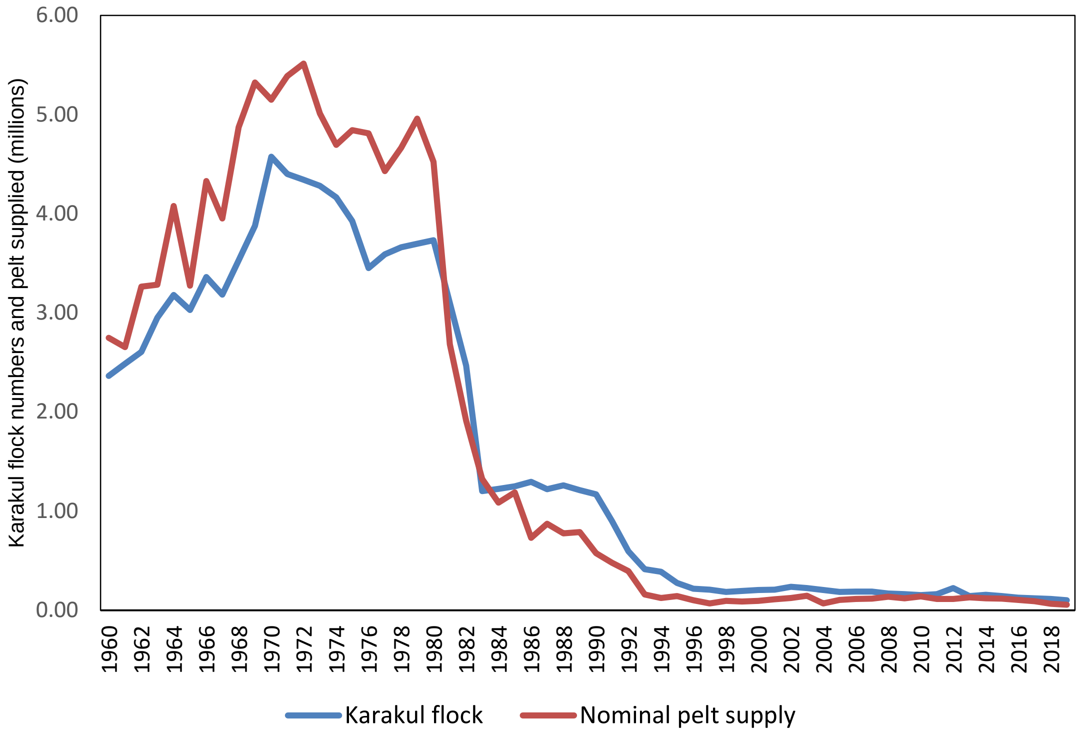


Figure 1: The Namibian Karakul flock and pelt supply (1960 – 2019)

Source: Author compilation, 2021

The Karakul sheep not only produce pelt but is also known for its lean and healthy mutton, dairy and wool. However, this paper did not assess these by-products, certainly with potential. Figure 2 shows the trend of Karakul pelt prices compared to the local mutton prices in comparison with the international fur prices for mink and chinchilla over time. This graph shows that there is much inconsistency paired with the movement of price, as fluctuations were seen between 2000 and 2019 in the fur market, while the mutton price showed a steady increase. This allows us to suspect volatility in the movement of fur prices. It is noted that the Mink fur and the Karakul pelt prices followed a similar upward trend until 2012 and a sharp decline since consumers' growing interest in environmental concerns, particularly among the young.

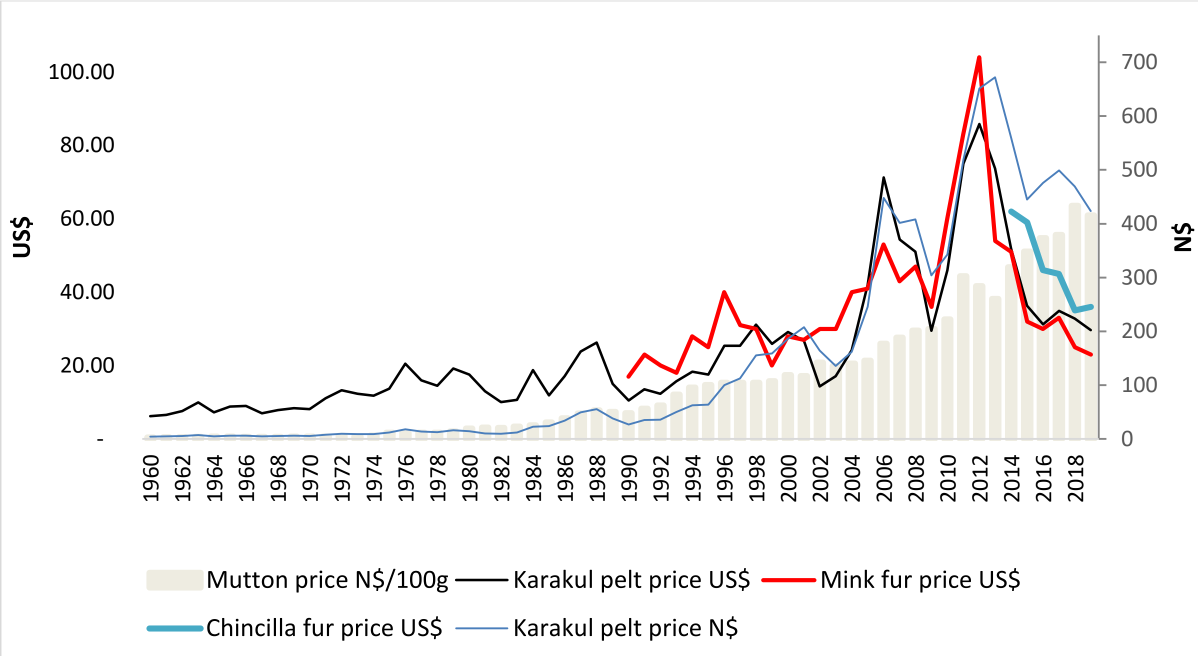


Figure 2: The Karakul prices in perspective (1960-2019)

Source: Adapted from The Karakul Board of Namibia (2020), NSA (2020), and Copenhagen Fur (2019)

## Methodology

### Model procedures

This study uses secondary data, mainly time-series quantitative data. Time series data requirements must be followed before the analysis. To comply with this requirement, a series of steps are followed to ensure the researcher considers and develops an analytical framework that aligns with developments in estimation techniques. The following steps were followed: (i) test the time series for stationarity to ensure that the model accounts for oscillations and that data exhibits stationary properties. Unit roots are essential as they can determine if the data set needs to be differenced first or regressed on deterministic functions of time to render the data stationary (Mushtaq, 2011). If the data is not tested for stationarity, the regression results will not be justifiable. (ii) normalise the data to account for anomalies in the dataset, (iii) deflate the financial data to account for inflation, and (iv) check for autocorrelation function (ACF) and a partial correlation function (PACF). It is crucial to note that the ACF describes how well the present values of the data series are related to its past values and that ACF considers all components, including trend, seasonality, cyclic and residual while finding correlations. In contrast, a PACF finds any hidden information in the data series, which can be used to model the subsequent lag. This makes it possible to get a good correlation possibly. The actual model estimation adopted the application of the Autoregressive distributed lag (ARDL), which comprised of estimating the long-run and Bounds test to check for a long-run relationship between the endogenous and exogenous variables. Subsequently, the autoregressive conditional heteroscedasticity (ARCH) and generalised Autoregression Conditional Heteroscedasticity (GARCH) were adopted to estimate the volatility in the karakul pelt price. ARCH and GARCH are useful to characterise time-varying attributes of the expected price and price volatility. To obtain robust results, a series of testing different types of symmetric, asymmetric, and nonlinear models were performed to aid in choosing the appropriate model to describe the expected price and price volatility for estimating a supply response model. The paper used Stata and EViews and was chosen strictly through preference.

**Data description and estimation procedure**

Table 1 presents the descriptive statistics of all variables with 60 observations. Small standard deviations of all series reflect that data are normally distributed. Time series annual data covering 1960 to 2019 for all variables were used. Local production and price for karakul and mutton and cost of production were obtained from The Karakul Board of Namibia and Meat Board of Namibia, exchange rate obtained from the Namibia Statistics Agency and the Bank of Namibia, and the international fur prices from the Copenhagen auction house.

Table 1. Data summary statistics

| Variable | Obs. | Mean | Std. Err. | Std. Dev. | Min | Max | [95% Conf. Interval] |
|---|---|---|---|---|---|---|---|
| **LPS** | 60 | 13.2969 | 0.2194 | 1.7000 | 10.8994 | 15.5228 | 12.8578 - 13.7361 |
| **LEXCH** | 60 | -0.9170 | 0.1415 | 1.0961 | -2.7232 | 0.35667 | -1.2001 -0.6338 |
| **LCOP** | 60 | 3.4247 | 0.2175 | 1.6849 | 1.0462 | 6.0840 | 2.9894- 3.8600 |
| **PPP** | 60 | 149.4007 | 25.1482 | 2.0061 | 3.5006 | 9.2017 | 99.0793 – 199.7221 |
| **MPP** | 60 | 10.3827 | 1.5569 | 1.7061 | 1.5466 | 7.1760 | 7.2672 – 13.4981 |
| **SOA** | 60 | 0.7333 | 0.0575 | 0.4459 | 0 | 1 | 0.6181 - 0.8485 |
| **LKAF** | 60 | -0.2712 | 0.1772 | 1.3733 | -2.2866 | 1.5201 | -0.6260- 0.0835 |

Note: LPS is the log of pelt supply (number in thousand), and EXCH is the exchange rate (US dollar). LCOP is the log of cost of production (Namibian dollar per kilogram), PPP is the average pelt producer prices, MPP is the mutton producer price, SOA is the social Awareness dummy (0 – where there was no SOA) and 1 - otherwise), and LKAF is the log of karakul flock (number).
Source: Author's calculations, 2021

Table 2 presents the VIF results and qualifies that the observed data do not exhibit an unnecessary level of collinearity.

Table 2: Variance inflation factor results

| Variable | VIF | 1/VIF |
|---|---|---|
| EXCH | 18.26 | 0.0547 |
| LKAF | 17.42 | 0.0573 |
| LMPP | 8.63 | 0.1158 |
| LPPP | 6.80 | 0.1469 |
| SOA | 3.36 | 0.2980 |
| Mean VIF | 10.89 | |

**Model Specifications**

This study develops an autoregressive distributed lag (ARDL) model to evaluate the supply response of karakul pelt production. ARDLs are standard least squares regressions that include lags of both the dependent variable and explanatory variables as regressors (Greene, 2003) The ARDL model has been used for decades to model the relationship between (economic) variables in a single-equation time-series setup. Its popularity also stems from the co-integration of nonstationary variables, equivalent to an error-correction (EC) process. The ARDL model has a reparameterisation in EC form (Engle & Granger, 1987 Hassler & Wolters, 2006). The existence of a long-run co-integrating relationship can be tested based on the EC representation. A bound testing procedure is available to draw conclusive inference without knowing whether the variables are integrated of order zero or one, I(0) or I(1), respectively (Pesaran *et al*., 2001). Subsequently, inference concerning the model's long-run properties is carried out using standard asymptotic normal theory (Pesaran *et al*., 1999). However, many alternatives to estimation and hypothesis testing have been developed for analysing series that are integrated of orders 1 and 0.

The advantage of the ARDL model is that it can analyse long-run relations when variables ($y_t$ and $X_t$) are I (1), I (0), or integrated. In this study, we estimate an ARDL system of karakul pelt production as independent variables and a series of determinants as exogenous variables. The equation is developed so that the independent variable is expressed as a function of past changes and present truncation of the exogenous determinants and one-period-lag error correction term to capture the deviations from the long-run equilibrium. In this paper, we consider the following ARDL (p, q) formation:

$$y_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{p} \emptyset_i y_{t-1} + \beta' X_t + \sum_{i=0}^{q-1} \beta_i^{*\prime} \Delta X_{t-i} + \mu_t, \qquad (1)$$

$$\Delta X_t = P_1 \Delta X_{t-1} + P_2 \Delta X_{t-2} + \cdots + P_s \Delta X_{t-s} + \varepsilon_t, \qquad (2)$$

Where $X_t$ is the *k*-dimensional I (1) exogenous variables (for example, dependent and independent variables) that are not co-integrated among themselves, $\mu_t$ and $\varepsilon_t$ are serially uncorrelated disturbances with zero means and constant variance-covariance. $P_i$ is $k \times k$ coefficient matrices such that the autoregressive vector process in $\Delta X_t$ is stable. $t = \max(p, q) \ldots T$, for simplicity, assume that the lag order $q$ is the same for all variables in the $K \times 1$ vector $x_t$. Alternatively, let $L$ denote the usual lag operator and define $\emptyset(L)$ and $\beta_j(L)$ as the lag polynomials:

$\emptyset_t = 1 - \sum_{i=1}^{p} \emptyset_i L^i and\ \beta_j(L) = 1 - \sum_{l_j}^{q} \beta_{j,l} L^{l_j}$Therefore, equation 1 can be expressed as:

$$\emptyset(L) y_t = \alpha_0 + \alpha_1 t + \sum_{j=1}^{k} \beta_j(L) x_{j,t} + \varepsilon_t \qquad (3)$$

The ARDL formulation qualifies the assumption that the roots of $1 - \sum_{i=1}^{p} \emptyset_i z^i = 0$ fall outside the unit circle, and a stable, unique long-run relationship exists between yt (endogenous variables) and xt. $\alpha_0, \alpha_1, \beta, \ldots\ \beta^*{}_1, \beta^*{}_{q-1}$ and $\emptyset = (\emptyset_1, \ldots, \emptyset_p)$ are parameters to be estimated. Following this general formulation, three alternative clarifications can be made. While all three can be used for parameter estimation, the first is typically used for intertemporal dynamic estimation and the second for the post-estimation derivation of the long-run (equilibrium) relationship. At the same time, the third is a reduction of (equation 1) to the conditional error correction (CEC) representation in the Pesaran (2001) bounds test. All three alternative representations make use of the Beveridge-Nelson decomposition. For conciseness, these alternative representations are not explained in this study. Thus, ARDL is preferred in this study because it can be applied to a small sample (Pesaran *et al*., 1999), and variables ($y_t$ and $X_t$) are I (1), I (0), or integrated.

The pelt production supply response equation is specified as:

$$LPS_t = a_0 + \beta_1 LPS_{t-n} + \beta_2 LCOP_t + \beta_3 LCOP_{t-n} + \beta_4 KAF_t + \beta_5 KAF_{t-n} + \beta_6 LPPP_t + \beta_7 LPPP_{t-n} + \beta_8 LMPP + \beta_9 SOA_t \quad (4)$$

where $LPS_t$ is the pelt supply for time t, $LPS_{t-n}$ is the pelt supply, LCOP is the cost of production lagged n years, $LMPP_t$ is the mutton price in time t, $LPPP_t$ is the pelt price in time t, $LPPP_{t-1}$ is the pelt price lagged n years, $LKAF_t$ is Karakul flock in current time, $LKAF_{t-n}$ is karakul flock lagged n years, and $SOA_t$ is social awareness in current
The karakul flock accounts for the influence of current and lagged flock numbers on the current supply of karakul pelts. The mutton prices determine the influence of current and lagged mutton prices on the current supply of karakul pelts. This accounts for the production theory of substitutability and competitiveness of pelf price to mutton price over time. The pelt supply lagged n years to measure the influence of the previous supply of pelts on the current supply of pelts. Variables are lagged because production needs time to adjust to a desirable level. The pelt price variance and expected pelt prices are important risk factors in this equation as they are from the volatility analysis; therefore, they are included in the estimation. Additionally, general equations for analysing volatility are given as follows:

Mean equation**:** $\mathrm{Y_t = X_t'\theta + \epsilon_t} \quad (5)$

Where $Y_t$ is pelt supply and $\theta$ is a function of exogenous variables. It is further specified as:

$$\mathrm{LPS = \beta_1 LMPP + \beta_2 LMPP + \beta_3 LCOP + \beta_4 LKAF + \beta_5 SOA + \epsilon_t} \quad (6)$$

Conditional Variance equation: $GARCH = \omega + X_t RESID_{-1}^2 \quad (7)$

Where ω is a constant term, and $\mathrm{RESID_{-1}}^2$ is the volatility from the previous period, measured as the lag of the squared residuals from the mean equation.

It is further specified as:

$$GARCH = \beta_6 + \beta_7 RESID_{-1}^2 \quad (8)$$

## Results and Discussions

### ARDL result for supply determinants for Karakul pelt

An autoregressive distributed lag model is selected using the Akaike info criterion (AIC). The AIC is a mathematical method for describing how well a model fits its generated data (Bevans, 2020). Bevans further states that it is calculated by using the number of independent variables used to build the model and the maximum likelihood estimate of the model. Compared to other competing models, the ARDL had the lowest AIC score, which strikes a superior balance between the ability to fit the dataset and its ability to avoid overfitting it. Burnham (2002) indicates that the model with the lowest AIC value is considered the 'best'.

Table 3: Results from ARDL model estimation

| Variable | Coefficient | Std. Error |
|---|---|---|
| **LPS (-1)** | 0.1970 | 0.1359 |
| **EXCH** | -0.5495* | 0.2213 |
| **SOA** | -0.0365* | 0.1060 |
| **MPP** | -0.0166* | 0.0074 |
| **PPP** | 0.0010** | 0.0005 |
| **PPP(-1)** | -0.0008 | 0.0008 |
| **PPP(-2)** | 0.0019* | 0.0006 |
| **LKAF** | 0.8877* | 0.1725 |
| **Constant** | 10.4004 | 1.7461 |

*denotes insignificance at the 5% level, and ** denotes the 10% significance level.

Table 3 shows that the exchange rate, pelt producer price lagged for two years, and karakul fur is significant and exhibits a positive relationship between current pelt supply. While the current pelt producer price (PPP) is positive and significant at the 10% level. Economic theory indicates that with an increase in own price, the supply increases, holding other shifters constant. The average pelt price received by producers in the previous year influences the current supply of pelts positively. This means that for every dollar increase in pelt prices in previous years, the current supply of pelts will increase by 0.0019 pelts, which is very inelastic.

The relationship between the average mutton price and pelt supply is harmful. This indicates that for every dollar increase in the price of mutton, the supply of pelts will decline by 0.0166. The exchange rate and the social awareness in the current time indicate a negative relationship with pelt supply and are significant at 5%. It proves that the exchange rate and social awareness significantly impact the karakul pelt supply over time.

A noteworthy result of the ARDL shows that social awareness, the proxy for the anti-fur movement, has a significant relationship with the supply of pelts. This indicates that the continuous supply of pelts was to some extent affected by the Anti-Fur Campaign, exchange rate, and mutton producer price, other than the own price in the current period.

### *Analysing the volatility of Karakul Pelt Supply*

Volatility is a statistical measure of the fluctuations of returns for a given commodity. The higher the volatility of a commodity, the riskier the investment because prices are often less predictable (Kuepper & Westfall, 2021). The ARCH test was used and is defined as the standard test used to detect autoregressive conditional variance. According to Berra and Higgins (1993), ARCH GARCH (1/1) models are simple and easy to handle, take care of clustered errors and nonlinearities, and take care of changes in the econometricians' ability to forecast. The estimated mean equation: ARCH/GARCH with a normal distribution (1,1) and is given as follows:

$$\text{LPS} = 8.6654\text{LPPP} - 0.1448\text{LMPP} - 17.0024\text{LCOP} + 1.3428\text{LKAF} + 0.0482SOA \qquad (9)$$

Table 4. ARCH/GARCH model results

| Variable | Coefficient | Z-Stat. | Prob. |
|---|---|---|---|
| **Constant** | 0.7673 | 2.46 | 0.014 |
| $\boldsymbol{RESID_{-1}}^{2}$ | 2.8956 | 4.71 | 0.0000 |

These results indicate that ARCH effects exist in the model and can be explained by the relatively high $R^2$, which is the coefficient of determination, as well as the residual value, which is the $\beta_7$ which is close to 3, which indicates high volatility. Volatility in agricultural commodities is not uncommon. However, this indicates that there may be high risks and can represent the unwillingness of farmers to produce more pelts and prevent prospective farmers from entering the industry.

### *Determine if there is a long-run relationship between variables*

Determining a long-run relationship is crucial as it indicates a theoretical concept that all markets are in equilibrium, inclusive of all prices and quantities having fully adjusted. A Long Run Form & Bounds Test suggests that the data series in both | (0) and | (1) is co-integrated, meaning they are bound together in the long run. The estimated Conditional Error Correction regression is given as follows:

$$EC = 0.5258LPS_{-1} + 7.2667LPPP - 12.8728LPPP_{-1} - 0.2375LMPP - 14.3097\text{LCOP} + 25.98987LCOP_{-1} + 0.3099\text{LKAF} + 0.3229LKAF_{-10} + 0.075SOA - 6.5941 \qquad (10)$$

This result indicates that a long-run relationship exists between pelt supply and pelt supply lagged one year, the average mutton price in the current time, and the karakul flock lagged one year. For every pelt increase in previous years, the pelt supply would increase by 0.5258 pelts in the long run. The same applies to the average mutton producer price, which is seen to have a significant negative relationship in the long run as well, decreasing the number of pelts supplied by 0.2375 units for every dollar increase in mutton prices. The empirical result matches the Namibian small stock censuses: many farmers slowly replaced their karakul stock with mutton sheep. Furthermore, a significant positive relationship is seen between karakul flock numbers in previous years and the current pelt supply, which indicates a 0.3229 increase in pelt supply for every head increase in the karakul flock. The listed variables impact the decisions for karakul farmers in Namibia.

**Error Correction Model**

An error correction model (ECM) is an econometric model that incorporates an instrument that restores a variable to its long-term relationship from a disequilibrium position (Clements, 2019). The ECM describes the short-run dynamics of the co-integrated variables towards their long-run equilibrium values. This error correction model indicates that if the average mutton price is above the long-run equilibrium with the market, it will be pulled down by -0.5010. It shows that if the Karakul flock number is below the long-run equilibrium, the Karakul flock will adjust and increase by 1.3394 heads and pull the flock back up to the equilibrium.

**Bounds Test:**

The Bounds test is based on the joint F-statistic, whose asymptotic distribution is non-standard under the null hypothesis of no co-integration. Two critical values for a given significance level can be determined (Pesaran *et al*., 2001). The first level is calculated assuming all variables in the ARDL model are integrated for order 0. In contrast, the second level is calculated assuming that the variables are combined for order 1. We accept the null hypothesis because the test statistic in order l (0) and l (1) are less than the F statistic. For each application, there is a band covering all the possible classifications of the variables into I (0) and I (1). However, according to (Narayan, 2005) the existing critical values in Pesaran *et al*. (2001) cannot be applied for small sample sizes as they are based on large sample sizes. Hence, Narayan (2005) provides a set of critical values for small sample sizes, ranging from 30 to 80 observations. Table 5 values, compared to the critical values are 2.496 - 3.346, 2.962 – 3.910, and 4.068 – 5.250 at 90%, 95%, and 99%, respectively.

Table 5. Bounds test for the co-integration result

| Test statistic | Value | Significance | l (0) | I (1) |
|---|---|---|---|---|
| F- STATISTIC | 6.745025 | 10% | 2.08 | 3 |
| k | 5 | 5% | 2.39 | 3.38 |
| | | 2.5% | 2.7 | 3.73 |
| | | 1% | 3.06 | 4.15 |

**Residual Diagnostics**

Residual diagnostics are presented in Table 6 to assess the appropriateness of a nonlinear regression model. Homoscedasticity describes a similar variance between all values of independent variables (Issa & Nadal, 2011). Homoscedasticity is crucial as it brings forward the ability to prove that relationships between variables are correct, relating the results in Table 2 to what is exhibited in Table 6. We do not reject the null hypothesis for all three tests because the Chi-Square probability is greater than 0.05.

Table 6: Diagnostic of Residuals

| **Method** | **Null Hypothesis** | **Obs*R-Squared** | **Prob. Chi-Square (5)** |
|---|---|---|---|
| Breusch-Pagan-Godfrey | Homoskedasticity | 5.1031 | 0.4034 |
| ARCH | Homoskedasticity | 1.5771 | 0.2092 |
| WHITE | Homoskedasticity | 13.6159 | 0.4787 |

### *Conclusion and policy recommendation*

Industries with high volatility, such as the Namibian Karakul industry, are easily influenced by pelt price fluctuations and are therefore a high risk when it comes to investment. This could be one reason why pelt supply has declined over the years. A possible solution would be to introduce exchange rate hedging systems, such as contracts which would coordinate the production process to reduce uncertainty and remove a portion of that risk. The paper empirically determined that the decline in supply is partly a result of the anti-fur campaigns of the 1970s and their continued advocacy of animal welfare groups. Furthermore, since the karakul pelt production depends on expected prices and not actual prices, the annual price fluctuations make it difficult for the producer's production since prices cannot serve as a proper signal. The results indicate that a long-run relationship exists between pelt supply and pelt supply lagged one-year, average mutton price in current time and karakul flock, lagged one year. This relationship indicates that the supply of pelts is nearly stable in the long run, regardless of the price pelt. In this regard, Namibian pelt farmers need to be advised on international demand, when to sell at the right price and to take advantage of the demand. New marketing strategies will require farmers' cash flow reserves to allow for more flexibility in their quality provision, to obtain a higher return over the long run. As many consumers follow environmental concerns, Swakara being natural and plastic-free[†], it should be marketed as a luxury and environmentally friendly product. The industry is called to seek alternative markets, get creative and seek ways to add value that might result in the creation of niche markets.

The paper showed that the Mink fur and the Karakul pelt prices follow similar trends. Further studies still need to be done to understand the mismatch between supply and demand by looking into farmer welfare. Understanding farmer experiences may give further insights to improve the sustainability of the sub-sector. The cost of production, for example, is increasing as seen in earlier trends. It will require a detailed value chain analysis based on the demand for Swakara pelts. By

[†] The awareness of animal abuse evoked the development of ethical alternatives, such as the growth of faux fur or artificial fur.

doing this, the government and various stakeholders need to work towards the modernisation and growth of the Swakara industry. It will require some adjustments to the Karakul Act (1982), Notices and Gazette to be sensitive to foreign currencies and supported production incentives for farmer welfare.

**References**


Berra, A. K., & Higgins, M. L. (1993). ARCH models: properties, estimation and testing. Journal of economic surveys, 7(4), 305-366.doi: 10.1111/l.1467-6419.1993.tb00170 Google Scholar Cross Ref

Bevans, R. (2020, March 26). An introduction to the Akaike information criterion. Retrieved December 14, 2020, from Scribbr: https://www.scribbr.com/statistics/akaike-information-criterion/Google Scholar

Bravenboer, B. (2007). Karakul: Gift from the Arid Land (Namibia 1907-2007). Windhoek, Khomas, Namibia: Karakul Board of Namibia, Karakul Breeders' Society of Namibia. Retrieved March 20, 2020, from http://namibia.leadr.msu.edu/items/show/157 Google Scholar

Burnham, K.P. and Anderson, D.R. (2002) Model Selection and Multimodel Inference: A Practical Information – Theoretic Approach. 2nd Edition, Springer Verlag, New York. DOI: https://doi.org/10.1007/b97636 Cross Ref

Clements, J. (2019, October 8). The Error-Correction Model for Co-integrated Time Series (and checking parameter stability). Retrieved December 15, 2020, from Towards Data Science: https://towardsdatascience.com/the-error-correction-model-for-co-integrated-time-series-and-checking-parameter-stability-a60bbdafb9e4

De Pinto, A., Smith, V.H. & Robertson, R.D. (2019).The role of risk in the context of climate change, land-use choices and crop production: Evidence from Zambia. Climate research. 79, no.1 (2019) 39–53. Google Scholar; Cross Ref

Engle, R. F., & Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica: journal of the Economic Society 55(2), 251–276. https://doi.org/10.2307/1913236 Google Scholar; Cross Ref

Ferdaws, N. A. (2015). How to develop Afghan karakul marketing. Master's Thesis International Business Management, Kyamk, Finland. Google Scholar

Frost, J. (2018). Model Specification: Choosing the Correct Regression Model. Statistics. Google Scholar.

Greene, W. H. (2003). Econometric analysis. Pearson Education India. Google Scholar; Cross Ref

Hansen, H. O. (2017). Global fur retail value. International Fur Federation. Retrieved from https://www.trappingtoday.com/fur-market/

Perasan, M. H., Shin, Y., & Smith R, J. (1999) Pooled Mean Group Estimation of Dynamic Heterigenous Panels. Journal of the American Statistical Association, 94(446), 621-634,DOI: 10.1080/01621459.1999.10474156 Cross Ref

Hassler, U., & Wolters, J. (2006). Autoregressive distributed lag models and cointegration. In Modern econometric analysis (pp. 57-72). Springer, Berlin, Heidelberg. Google Scholar; Cross Ref

Issa, M. A. & Nadal, K. L. (2010), Homoscedasticity. In S. Goldstein & J. Naglieri (Eds.), Encyclopedia of Child Behavior and Development (p. 752). New York: Springer Cross Ref

Keet, JDM (1949). Report on the long-term agricultural policy commission, Windhoek Google Scholar

Kuepper, J., & Westfall, P. (2021). Volatility, Investopedia. Library Catalog: www. investopedia. com,[Online]. Available: https://www. investopedia. com/terms/v/volatility. asp (visited on 07/22/2020)(cit. on p. 18). Google Scholar

Mushtaq, R. (2011). Augmented Dickey Fuller test. Google Scholar; Cross Ref

Narayan, P.K (2005). The saving and investment nexus for China: evidence from cointegration tests. Applied Economics, 37(17), 1979-1990. Google Scholar; Cross Ref

Namibia Statistics Agency. (2019). Annual National Accounts 2019. Windhoek: Namibia Statistcs Agency. NSA National Accounts 2019

NOAH, (2015). Case Saga Furs Nordic fur trade. https://www.furfreealliance.com/wp-content/uploads/2015/10/Pels_final_print_mail.pdf

Pesaran, M.H., Shin, Y., and Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Economics, 16, 289-326.Google Scholar; Cross Ref

The Namibian. (2007, September 17). 100 Years of the karakul industry in Namibia 1907 - 2007. Retrieved March 03, 2020, from namibian.com.na: https://www.namibian.com.na/39497/archive-read/100-Years-of-the-karakul-industry-in-Namibia-1907---2007#

Visser, J. (2012, August 7). The Rise of Swakara Farming. Farmer's Weekly, pp. 1-5. Retrieved March 20, 2020, from https://www.farmersweekly.co.za/animals/sheep-goats/the-rise-of -swakara-farming/