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Determinants of Beef Meat Supply in Burundi: A Vector Error Correction Model Approach Applied to structural Nerlov Paradign

W-M. Ndayitwayeko[1], M.O. Odhiambo[2], P.M. Nyangweso[3] And M. Korir[4]

[1]*Department of Rural Economics, FSEA, University of Burundi, B.P. 1550 Bujumbura, Burundi, Email address:* ndayiwm@googlemail.com

[2]*Department of Agricultural Economics and Resource Management, SBE, Moi University, P.O. Box 3900, Eldoret, Kenya. Email address:* mooodhiambo@yahoo.com

[3]*Department of Agricultural Economics and Resource Management, SBE, Moi University, P.O. Box 3900, Eldoret, Kenya. Email addressphiloe2000@yahoo.com*

[4]*Department of Economics, SBE, Moi University, P.O. Box 3900, Eldoret, Kenya. Email address:* korirmk@gmail.com

*Corresponding author is currently a PhD student, Moi University, SBE, Department of Agricultural Economics and Resource Management.

Abstract

The issue of beef meat supply response is an important one as it has an impact on production, nutrition, and poverty alleviation. The traditional beef meat supply that characterizes the livestock sector of Burundi may be unsustainable in providing the desired amount of food meat to the growing population and may be chocked off by a stiff competition in the regional trade agreement, COMESA and EAC where South Africa, Botswana and Kenya are the leading beef meat suppliers. This paper mainly aims to determine factors affecting beef meat supply in Bujumbura based on the structural Nerlov paradigm. Time series analysis was used on annual data for a period of 40 years (1970-2010). Both co-integration and Vector Error Correction Model (VECM) were used to fine tune the Nerlov model and determine the long-run and short-run relationships between the variables of interest. Empirical results show that the long-run relationship exists through co-integration tests and beef price supply is inelastic ($\varepsilon = 0.8$) as it has been expected. The speed adjustment coefficient of partial adjustment of 18% indicates that there exist some production costs that slow and retard the beef supply function to adjust to price variation. Clear mechanisms to link beef and cattle producers to market and slaughterhouses in Burundi are desirable in order to reduce or eliminate factors that constrain beef supply in Burundi.

Key Words: *Beef meat supply, Burundi, Nerlove model and VECM*

Introduction

Burundi meat supply is challenged by low meat added value due to lack of meat processing units and inadequacy of conservation infrastructure (cold room), poorly equipped slaughter houses and a market marked by incessant supply and demand price volatility due to both conjectural and structural phenomena (GoB, 2006, p.33 and Nahimana, 2000). The other impediment is the social status that the pure bred or crossbred Ankole cattle play in the Burundi tradition and make it difficult for the producer to depart from it (Sebushahu, 2011, FAO, 2008, p.54 and World Bank, 2008, p.65) or at some extent, cattle is preferably kept for milk and manure production (Branckaert and Mack, 1993). Furthermore, the integration of Burundi to East Africa Community (EAC) and the signed agreement of creation of Custom union and Common Market may either complicate or easy the issues of meat supply in Burundi. Hence, Burundi will be willing either to restructure and modernize its meat supply chain or be ready to be flooded by beef meat from Tanzania and Kenya which have comparative and competitive advantages in the meat sector. Against this backdrop, beef meat is a source of income and proteins for a balanced nutrition in Burundi. In this paper, the aim is to find out the factors that influence beef meat supply in the urban markets (Bujumbura) through the supply response analysis.

The concept of supply response is dynamic and different from supply function which is static. Referring to Askari and Cummings (1976), Apostopoulos and Stoforos (2002) stated that factors influencing dynamic supply response have been the subject of considerable research. The response relation is very meaningful in the agricultural supply because it shows the change in quantity with change in prices and supply shifters and, therefore approximates to the long run, a dynamic concept of supply theory. Empirically, there is a great wealth of literature on the agricultural supply response dealing with crop or animal product (Rucker *et al*., 1984, Hennebery and Tweeten,1996, Palanivel, 1995, Mishra, 1998; Mushataq and Dawson, 2002 and Mythili, 2008).

Materials and Methods

The major impediment in the agriculture sector is that the prices are known after the production has occurred and this slightly causes a difficulty when it comes to price forecast.

The adaptive expectation is considered in this paper as simple and flexible in the model estimation. Proposed by Cagan (1956), it was refined to more articulate on partial adjustment expectation by Koyck (1954) and later on by Nerlove (1956, 1958). In integrating price in supply response studies, the economists used either the direct or indirect structural form approaches. Indirect structural approach involves a rigorous derivation of input supply and demand functions from the available data by wrapping up together the information related to the production function and producer's behaviour. This approach appears to be very interesting and data-demanding, but is not applied in this study.

The direct structural form approach gives an estimation based on both partial adjustment and expectation formation in a much known Nerlovian model. As reported by Antonova and Zeller (2007), the latter is a partial adjustment supply response model, dynamic by nature and heterogeneous by commodity structure. Given the following supply equation:

$$Q_t = \beta_0 + \beta_1 P_t + u_t \quad (1)$$

The Nerlovian supply response model is usually built based on the following two assumptions:

$$Q_t - Q_{t-1} = \delta(Q_t^* - Q_{t-1}) \quad (2)$$

$$P_t^* - P_{t-1}^* = \lambda\left(P_{t-1} - P_{t-1}^*\right) \quad (3)$$

Where:

Q_t = quantity of meat (in tons) in time t,

Q_{t-1}= quantity of meat in time t-1 (lagged once),

Q^*_t = desired quantity of meat in time t,

P_t = actual price of meat (in FBu) in time t,

P^*_t = Expected normal price in t for next future period,

P^*_{t-1} = Expected normal price in t-1,

δ = Coefficient for quantity of meat adjustment,

λ = Coefficient for price expectation.

The dynamic adjustment supply response equations are equations (2) and (3) are based on the fact that each year meat producers revise the output level and price that they expect to prevail in the coming year. In equation (2), the assumption holds that the producer adjusts output Q_t to the optimal or desired level of Q^*_t. If Q^*_t is a desired quantity of meat, this optimal level may not be attained instantaneously because of costs involved and technology. Therefore, the observed level of the variable reflects the partial adjustment from current to the optimal levels. The equation (3) refers to the naïve price expectation or price expectation component. According to Nerlove (1956), each year, farmers revise the price that they expect to prevail in the coming year in proportion to the error they made in predicting price this period.

This is done in proportion to the error farmers made in predicting the output level and price of the same period, that is, δ and $\lambda \in [0,1]$ as a coefficient of adjustment. It indicates the speed of adjustment between desired and actual meat supply in the previous period. If δ and λ approached to zero, it means that there is no change from year to year and if δ and λ=1, the adjustment is instantaneous.

Substitutions and additions are done in order to derive equation (4) to which exogenous supply shifters (Z_t) are added.

$$Q^*_t = \beta_0 + \sum_{t=1}^{\infty} \beta_i P^*_{t-i} + \gamma Z_t + \varepsilon_t \quad (4)$$

Z_t is a set of exogenous supply shifters such as price of the substitute or complementary product, technology change, consumer's income, taste and preferences, etc. at period t.

ε_t = stochastic error term, β_0, β_i and γ = coefficients of regression where $\beta_i = \beta\lambda^i$, (λ^i = weights), $0<\lambda<1$ to be estimated and i = 1, 2, 3, ∞.

In the equation (4), β_i exhibits a declining function time lag as it is shown in this elaborated geometric distributed lag model if the exogenous supply variable is imputed for convenience purpose. However, one way to reduce the number of lags is done following this procedure proposed by Koyck (1954).

The response model in this study was estimated with this long-run supply function:

$LTEC_t$ = constant + β_1LBPRICEt$_{-1}$ + β_2 LGPRICEt$_{-1}$ β_2LGDPCAPIT$_{t-1}$ + LRF$_{t-1}$ + DUMM1973 +DUMM1983 + DUMM1994 + ε_t (5)

Where, $LTEC_t$= log of tons of equivalence of carcass at time t,

$LBPRICE_{t-1}$ = log of expected real beef price at time t-1,

$LGPRICE_{t-1}$ = log of expected real goat meat price at time t-1,

$LGDPCAP_{t-1}$ = log of GDP per capita at time t-1,

LRF_{t-1} = log of annual Rainfall at time t-1,

DUMM1973: Dummy that capture civil war of 1972 (year 1973=1 and 0= otherwise),

DUMM1983 = Dummy to capture the eruption of cattle disease in 1982 (year 1983 =1 and 0= otherwise), i.e. apthous fever and foot-and-mouth diseases.

DUMM1994 = Civil war and economic embargo from period 1993 to 2000 (1994 to 2000 = 1 and 0 otherwise)

ADF, PP and KPSS tests of stationarity were applied in this study Vector Error Correction Model (VECM) and co-integration analyses were also carried out. We chose the Johansen co-integration procedure (Johansen, 1988). This procedure follows a Maximum Likelihood Approach (ML) and is formulated as follows:

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \ldots + \Gamma_{k-1} \Delta Z_{t-k+1} + \Pi Z_{t-k} + \Psi X_t + u_t \quad (6)$$

Where Z_t is a vector of I (1) endogenous variables, $\Delta Z = Z_t - Z_{t-1}$ and Xt is a vector of I (0) exogenous variables. Γ_i, Π and Ψ are (n x n) vector matrices of parameters. The above equation (6) contains the short-run and long-run adjustment to changes in Z_t represented by Γ_i and Π respectively. In co-integration analysis, the number of co-integrating relationship are given by the rank of Π and are denoted by r and trace statistics are used to test the null hypothesis of at most r co-integrating vectors against the alternative that the number of co-integrating vectors is greater than r.

The second step was to estimate the Vector Error Correction Model (VECM) in order to examine the existence of the long-run and short-run relationship among variables through autoregressive lags following Hallam and Zanoli (1993). The Vector Autoregressive (VAR) represented by equation (7) has to be turned into equation (8) of VECM.

$$Z_t = \beta_0 + \beta_1 Z_{t-1} + \beta_2 Z_{t-2} + \ldots + \beta_k Z_{t-k} + \varepsilon_t \quad (7)$$

And

$$\Delta Z_t = \Gamma_1 \Delta Z_{t-1} + \Gamma_2 \Delta Z_{t-2} + \ldots + \Gamma_{k-1} \Delta Z_{t-(k-1)} + \Pi Z_{t-k} + \varepsilon_t \quad (8)$$

The vector Z_t includes beef meat carcass, beef own price, goat price, GDP per capita and rainfall, that is, Z_t = [BP, GMP, GDPCAP, RF]. $\boldsymbol{\Gamma_1, \ldots, \Gamma_{k-1}}$ are vectors of the short-run parameters while $\boldsymbol{\Pi = \alpha\beta}$ is a matrix in which $\boldsymbol{\alpha}$ represents the speed of adjustment and $\boldsymbol{\beta}$ represents (n-1) co-integrating relationships among non-stationarity variables.

The final model was subjected to a series of diagnostic tests for validation purposes. The parameters were tested by t-student test and the residuals by both JB_{Urzua} test for normality and LM serial autocorrelation test.

The sample period of all series is 1970 to 2010. The data for the quantity production of beef and price index of beef (base year 1998) are published by the department of livestock of ministry of agriculture (MINAGRI) and central bank (BRB) of Burundi. Bujumbura Slaughter House (BSH) records the volume and number of cattle before and after the slaughtering process, the beef production made for the Central Market of Bujumbura is also recorded. The private beef traders, once receiving the BSH service, prepare the carcass themselves outside the BSH. Other sources of data were Bureau of Statistics of Burundi (ISTEEBU) and FAOSTAT.

Results and Discussions

In table 1, the tests for stationarity reveals mixed ADF and KPSS results. Both ADF tests in levels either with intercept only or intercept and trend accept the null hypothesis, that is, there is no stationarity; whilst KPSS test also rejects the null hypothesis. The overall outcome is that the data series have unit root since they are upward trending and are first difference stationary. Hence, the variables are integrated of order 1, i.e., I(1), in levels and can be subjected to Johansen long-run co-integration test to see whether there exist any linear combination of five variables that have common trend.

Table 1 Unit Root Tests in Level

Variables	ADF Stat.		KPSS	
	Intercept alone	Intercept & Trend	Intercept alone	Intercept & Trend
LTEC	-2.9368	-3.5266	0.4630	0.1460
	(-2.2438) A	-2.0551 A	(0.5701) R	(0.1839) R
LBPRICE	-2.9390	-3.5298	0.4630	0.1460
	(-1.6823) A	(-1.9199) A	(0.6676) R	(0.1754) R
LGPRICE	-2.9369	-3.5266	0.4630	0.1460
	(-1.7362) A	(-2.3000) A	(0.5989) R	(0.1455) A
LGDPCAPIT	-2.9400	-3.5300	0.4630	0.1460
	(-2.0785) A	(-2.1173) A	(0.1538) A	(0.1569) R
LRF	-2.9370	-3.5266	0.4630	0.1460
	(-1.5140) A	(-1.4449) A	(0.1563) A	(0.1541) A
ΔLTEC	-2.9390*	-3.5298*	0.4630	0.1460
	(-7.5566) R	(-7.7378) R	(0.3048) A	(0.2630) R
ΔLBPRICE	-2.9390*	-3.5298*	0.4630	0.1460
	(-10.7367) R	(-10.7295) R	(0.5000) R	(0.3143) R
ΔLGPRICE	-2.9390*	-3.5298*	0.4630	0.1460
	(-7.1343) R	(-7.0530) R	(0.1455) A	(0.1147) A
ΔLGDPCAPIT	-2.9400*	-3.5300**	0.4630	0.1460
	(-3.7778) R	(-3.7730) R	(0.2380) A	(0.1723) R
ΔLRF	-2.9390*	-3.5300*	0.4630	0.1460
	(-6.8320) R	(-6.8400) R	(0.1783) A	(0.0707) A

*Note: * significant at 1%, ** significant at 5% and ( ) denote critical value. A = Accept null hypothesis and R = reject null hypothesis (ADF: Ho: there is unit root, KPSS: Ho: there is no unit root)*

Source: Author's calculations, 2012

Following Johansen procedure of trace statistics and maximal eigenvalue statistics, the co-integration rank shows in Table 2 that the rank of selection depicts four co-integrating vectors- are found in this model (r = 4).

Table 2: Co-integration test, trace statistics

Ho No of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	P-Value
None *	0.9655	328.8188	159.5297	0.0000
At most 1 *	0.8657	200.8893	125.6154	0.0000
At most 2 *	0.6783	124.6064	95.7537	0.0001
At most 3 *	0.6054	81.5123	69.8189	0.0044
At most 4	0.4459	46.1746	47.8561	0.0713

Note: 4 lags were selected according to AIC criterion. Trace test indicates 4 co-integrating vectors at 5% level.

Source: Author's calculations, 2012

The statistical evidence of co-integration validates the theory of long-run equilibrium between supply, price and other exogenous variables. The results of both long-run and short-run parameters are reported in the appendix (Table 3).

In this model of beef supply response, the Lagrangian Multiplier (LM) test of serial residual autocorrelation at 4 lags yields χ^2 = 93.01 (p>0.05) accepting thus the null hypothesis of no residual autocorrelation and the Jarque-Bera normality test via Urzua factorization is χ^2 = 4.2 (p>0.05) suggest that the residuals are well-behaved and is an indicator that the model is also well specified. Moreover, the signs of the coefficients meet a priori expectation, expect that of rainfall variable. The signs of dummies present a mixed expectation.

Table 3: Beef Supply Response Vector Error Correction Model

	LONG-RUN RELATIONSHIP							
COINT.EQ	**CONTEQ1**							
LTEC(-1)	1.00							
LBPRICE(-1)	0.80[5.73]							
LGPRICE(-1)	-1.33[-8.37]							
LGDPCAPIT(-1)	1.13[10.44]							
LRF(-1)	-1.31[-7.74]							
DUM1973(-1)	4.65[15.30]							
DUM1983(-1)	-0.16[-0.63]							
DUM1994(-1)	1.59[16.97]							
C	-5.04							
SHORT-RUN RELATIONSHIP								
Error Correction	**D(LTEC)**	**D(LBPRICE)**	**D(LGPRICE)**	**D(LGDPCAPIT)**	**D(LRF)**	**D(DUM 1973)**	**D(DUM 1983)**	**D(DUM 1994)**
CointEq1	-0.19	-0.11	-0.05	-0.10	-0.03	-0.27	-0.14	-0.20
	[-1.8]	[-0.9]	[-0.4]	[-2.6]	[-0.5]	[-3.7]	[-1.7]	[-1.7]
D(LTEC(-1))	-0.38	0.53	-0.12	0.10	0.09	0.0	0.04	0.03
	[-1.7]	[2.0]	[-0.4]	[1.2]	[0.7]	4[0.2]	[0.2]	[0.1]
D(LTEC(-2))	…	…	…	…	…	…	…	…
D(LBPRICE(-1))	0.68	-0.33	-0.09	-0.09	0.12	0.20	-0.01	-0.21
	[2.5]	[-1.0]	[-0.3]	[-0.9]	[0.8]	[1.1]	[-0.04]	[-0.7]
D(LBPRICE(-2))	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…
C	0.039	0.08	0.06	0.02	-0.00	0.00	-0.00	0.03
	[0.9]	[1.5]	[1.1]	[0.9]	[-0.1]	[0.1]	[-0.0]	[0.6]
R-squared	**0.53**	**0.61**	**0.26**	**0.64**	**0.27**	**0.72**	**0.63**	**0.27**
DIAGNOSTIC TESTS								
LM serial correlation test (up to 4 lags): LM test χ^2 =23.88 (p=0.09), Normality JB_{CHOL}) test: χ^2 = 8.50 (p=0.38), White test: 205.89(p=0.09), R^2=0.51								

Note: [ ] denotes T-stat. values and … denotes values not shown for simplicity.

Source: Author's calculations, 2012

The data being in logs, coefficients of the model represent long-run elasticities, rather than impact multipliers, of beef supply with respect to own price, price of substitute (goat meat) and consumer price index. The long-run relationship among variables is depicted by this supply response equation whose coefficients are picked from the upper part of the table 3:

$LTEC_t = 2.73 + 0.80LBPRICE_{t-1} – 1.33LGPRICE_{t-1} + 1.13LGDPCAPIT_{t-1} – 1.31LRF_{t-1} +$

$4.5DUMM1973 – 0.16DUMM1983 + 1.59DUMM1994$ (9)

The equation (9) indicates that 1 unit increase in expected beef purchase price induces a significant increase of 0.8 unit of beef supply. This is consistent with the theory of supply whereby an increase in own price triggers an increase of supply of commodity, ceteris paribus. The long-run inelasticity that marks the beef supply calls for police-makers' attention because in many instances beef supply, a commodity not reachable to all, has a normal supply elasticity. However, due to the lower purchasing power of urban Burundians and the abundance of alternative sources of proteins, the outcome of this VEC model makes sense.

Nevertheless, a 1 unit increase in both expected goat meat price and rainfall causes a decline of beef supply by 1.33 and 1.31 respectively. With increase of beef supply caused by a hike of its price would lead to a decline of the price of its substitute (goat). The same can be said for the rainfall. As pointed earlier, the sign of rainfall variable was not expected, though it is statistically significant. One important result is the impact of purchasing power of the beef consumer which shows a significant and positive effect. This finding is consistent with that of Unnevehr and Khoju (2008) who found that the income of consumers explains the large proportion of the meat consumption variance, rather than tastes.

The middle part of table 3, the results show the short-run dynamics of the VECM model of the beef supply in Burundi. The error correction coefficients (**α** vector of speed adjustment, equation (8) and their corresponding t statistics are in the first raw. They measure how fast the system returns to its long-run equilibrium when an exogenous shock strikes. The error correction coefficient (-0.187865) carries the expected negative sign and is significant at 5% level. This indicates a feedback of 18.79% of the previous year's disequilibrium from the long-run elasticity of beef price. This implies that the speed with which beef price adjust from short-run disequilibrium to changes in beef supply in order to attain long-run equilibrium is 18.79% within one year. The GDP per capita shows also an interesting result. Its speed of adjustment is 10% and statistically significant ($p<0.05$).

However, other adjustment coefficients, such as that of GPRICE has the expected sign but is not significant and dummies, both unexpected signs, are not significant in short-run relationship span. All lagged adjustment is being done by LTEC (beef supply) if we consider the second column of table 4 where many coefficients present a statistical significance. Elsewhere, there are mixed results. If there is not a significant adjustment coefficient, this aspect means that the short-run equation does not adjust to deviation from the long-run equilibrium, that is, it is weakly exogenous on long-run. The results of this paper lends supports at some extent to previous studies that beef sector enjoys an elastic supply in agriculture (Apostolopoulos and Storofos, 1997, Aadland *et al.,* 2000 and Mbaga and Coyle, 2003).

Conclusions and Recommendations

This paper aims at finding the determinants of beef supply response in Burundi. The livestock production of Burundi has been in decline due to the decade straining civil war. The country relied mostly on the import of cattle from Tanzania to solve the shortage of beef production in Burundi and to boost its low livestock breeding stocks. The findings revealed a long-run co-integrating relationship between beef production, expected beef producer price, expected goat meat price (price of substitute), expected GDP per capita, rainfall, as well as an inelastic beef supply in the long-run. In the short-run, the adjustment of beef supply to equilibrium is slow (18%) when a shock occurs. This factor is attributed to the consumption patterns of Burundians. Basically, beef meat is affordable by high income earners because of its high price. The low income class looks for other source of animal proteins instead of beef meat, such as rabbit, chicken, etc. Hence, in the occurrence of any shock, the speed to adjustment is low. In order to bolster beef supply, mechanisms in the form of production and marketing policies have to be put in place so that the constrains linked to production should be relaxed and regulation of beef price be enhanced to make it accessible to the low income earned. A modernized livestock system that can boost beef supply is warranted.

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