WIJAS 2: 33–44 (2020)

Welwitschia International Journal of Agricultural Sciences (WIJAS)

W I J A S

http://www.unam.na E.mail: editor4wijas@unam.na (+264) (0) 61 206 3111

unam FANR PUBLICATION

Application of dynamic modelling in determining drivers of profitability in Namibian cattle farming: A case study of northwestern Namibia

Helmke Jens Sartorious von Bach and Kennedy Muzamai Kalundu

Agricultural Economics, University of Namibia, Windhoek, Namibia

Abstract

The continuous changes in the economic, social and physical agricultural environment call for resilient livestock production systems and food chain networks around the world and Namibia in particular. Because of the low profitability, cattle farming in Namibia is heavily dependent on correct decision making for farmers to survive. The study hypotheses that prior knowledge of economic, social and physical environment improves profitability that leads to increased net worth. In this study, net worth at farm level refers to the cattle stock. The paper employed ordinary least square and dynamic models to investigate farmer's net worth in livestock production systems as a function of herd size per hectare, carcass price per kilogram and the El Niño Southern Oscillation Index. Results show that herd size per hectare significantly impacts net worth without prior knowledge about 1.627 per cent while exhibiting the impact of 1.523 per cent on the net worth with prior product knowledge. Farmers become more responsive to carcass price per kilogramme (increases net worth by 1.131 per cent) when prior information is incorporated in the decision-making process. The price elasticity of the two models is 0.60 and 0.70, respectively. The study points out that improved access to knowledge leads to increased profitability and net worth by 10 per cent. The significance of these variables calls for introducing early warning systems to mitigate the impact of changes on cattle production and the agribusiness sector.

Keywords: arid environment, cattle production, dynamic modelling, drivers of profitability, Namibia, net worth.

1. Introduction

Cattle and beef production is the largest agricultural sector in Namibia. The value of cattle and beef output in 2019 was N$3.2 billion, 46.6% of total agricultural output (NAU, 2020). Despite the importance of beef cattle farming to the national economy, profitability at farm level is meagre and declining, with average

---

Received 24 June 2020. Received in revised form 04 August 2020. Accepted 30 August 2020. Available online 07 December 2020. * Corresponding author: HJ Sartorius von Bach (Tel: +264 811280929, E-mail: svonbach@unam.na).

family farm gross margin for selected farms in 2019 at N$10.76/ha (Mopane, 2019). Cattle farming in Namibia is heavily dependent on continuous adjustments for farmers to remain viable. However, there are several management steps which have the potential to increase profitability, especially for north-western Namibian beef farms substantially.

Significant changes in the economic, social and physical environment call for resilient livestock production systems and food chain networks around the world. New farming practices and technologies are required to build appropriate systems for improving the profitability of the complete supply chain (O'Leary et al., 2018 and Sartorius von Bach and Kalundu 2019a). It involves decision-making in the face of increasing complexity and uncertainty. In this paper, information is exclusively referenced to mean access to timely knowledge about the occurrence of poor rainfall patterns and periodicity. Farmers act swiftly to adjust the cattle stocking rates on the farm to circumvent the perceived impact of poor rangeland conditions. Such information can be provided through access to digital tools and interactive technologies for farming systems. Access to digital tools and interactive technologies for farming systems has increased rapidly, and it is likely to play a significant role in meeting future challenges (Asplund et al., 2019). This would impact on the conventional livestock production wisdom that the rangeland condition is core to sustainable livestock operation (Dunn et al., 2010 and Locke, 2013). In Namibia, cattle production has been widely analysed, but the dismay is that most variables included for modelling have yielded inconclusive results on farm business performance. Therefore, it is argued here that the key determinants of profitability have to be correctly analysed for incorporation in decision-making to be fully integrated with the latest technological support measures.

This paper develops its novelty from an earlier Namibian research work (Sartorius von Bach and Kalundu, 2019a) that concluded that applied knowledge on weather patterns contributed about 16% to improved gross margins for ox production systems. Taking into consideration that conventional wisdom from supply-side economics postulation that beef prices, offtake and production output and production cost savers are the main determinants of profitability (O'Leary et al., 2018). However, the production environment in north-western Namibia is such that output and offtake rate are the significant drivers of success and that prices are non-responsive in that arid environment. By definition, the offtake rate is the percentage of biomass expressed in kilogrammes, removed from the total biomass of cattle stock on a farm.
The paper hypothesizes that improved technologies and access to knowledge will shift the production frontier in beef production and consequently improve the profitability and equity of the sector. This is tested with time-series data from commercial livestock farmers in north-west Namibia. A stepwise approach with causality testing of variables will determine which production variables will significantly contribute towards improved profitability. The paper will also take into account some weather variables, such as the El Niño–Southern Oscillation (ENSO) Kane (2009), and augment to cattle farming profitability. Therefore, the case study will not only guide decision making in livestock production but will also benefit the agribusiness sector by linking production to climate adaptability for resilient food markets. This calls for discussions on adjusted policy instruments that should be geared towards the management of the fragile farm environment, and to introduce measures to mitigate the impact of climate change on cattle production and profitability.

2. Gross margin and Equity considerations in cattle production

The fundamental accounting identity for cattle production is that production output is the result of the selling of finished cattle, stores, cull cows, replacements, weaners, breeding bulls and sometimes income from direct payments. Conversely, farm expenses include cattle stock purchases, feed, labour, machinery operational costs, veterinary costs, capital spending and loan repayment, and this implies expenditure on land, buildings and machinery. The critical parameters to farmers are the stocking rate of the farm, expressed as the broad stock unit per hectare, and it measures the current level of stock carried on the farm across all categories of stock.The next parameter is the kilogram of live weight output evaluated per livestock unit and per hectare farm. These measures take into account individual animal performance (live weight gain) and stocking rate. The quantity of live weight sold has a significant influence on the gross output in monetary terms or Namibian dollar equivalent.

Variable costs are linked to the production system in operation, and the level of production (output per hectare) and are deducted from the gross output to leave a gross margin. In contrast, fixed costs are deducted from gross margin to obtain Net Profit. The latter is defined as the margin-left after all farm-related costs have been settled. The farmer records the whole farm net profit with all direct payments included based on the total area farmed in a specific year.

Given the above summary on the gross margin, it occurs that in periods of a low margin, volatile price and rainfall, enterprises like some beef cattle producers cannot service debt. This places extreme pressure on the farm operation decision making processes of the farmer. For example, Dunn et al. (2010) suggest that the viability of a farm that cannot continuously invest cash, even if the farm is asset rich, may fail. Therefore, farmers without cashflow will not be able to modernise. This is the tipping point where farmers evoke on alternative options such as to use their equity to salvage the farm operation. Equity in this paper was defined as the value of livestock capital per hectare and considered to be cumulative over the good years (years of increased stocking rate on a farm operation). This variable includes the value of the annual deflated cattle herd plus the gross margin generated from production.

For Namibia, the relative volatility of climatic conditions at different production years along the beef supply chain has been relatively consistent through time. While climatic conditions have been erratic, beef cattle herds have moved downwards since 2014, in tandem to the situation for beef cattle farmers, have not experienced an increase in the degree of output gains experienced during climatic volatility years. The profitability of a given cattle enterprise can be affected by movements in the prices of cattle bought or sold and more so the quality of the animals at the time of selling related to the quality of the grasslands (Dunn et al., 2010). In general, changes in cattle prices and condition of the veld, given the nature of the climatic condition before marketing, will have a more significant impact on margins earned on cattle-rearing extensive grass-fed farms, than farms that purchase calves or weaners and sell finished store cattle.

3. Methodology

3.1 Data and preliminary analysis

The paper used aggregated annual time series data from 1992 to 2019 for northwestern Namibia. The broad stock commercial production area is classified as arid bush savannah with granite hills and dry riverine. Farmers in that production area follow a beef production system, described as a calf to ox production. The production practice is executed on extensive pastures, where cattle are roaming freely. Production data indicates that the stocking rate of 25 kg biomass per hectare is low because of the aridity of the area. There is no feed system, and the practice can be regarded as organic and natural. About a third of the cattle herd in the area consists of breeding stock for the production of weaners. The weaners are raised to become oxen. Oxen are sold and slaughtered at the export abattoirs when they are between 27 to 30 months old. Table 1 and Figure 1 illustrate an overview of the production over the 27 years' time horizon. Over 27 years, data shows that most production variables (where the production costs were derived) have a relatively small coefficient of variation, except the offtake rate with 43.8%. The cost of production variables had the highest coefficients of variation between 30% and 45%. In general, data show growth, except the surface size, herd size, number of cow's variables, and the capital value of the livestock.

Table 1: Descriptive statistics of production variables

Variable	Average	Median	CV	Slope
Total surface	9 150 ha	9 074 ha	12.4%	-75.01/yr
Herd size per stocking rate	475 LSU	479 LSU	15.4%	-3.02/yr
Number of cows (herd) per farm	166	168	12.5%	-0.21/yr
Calf percentage	76.3%	79.0%	8.9%	3.43/yr
Weaning mass (kg)	201.3	202.1	5.8%	3.41/yr
Stocking rate	22.4kg/ha	22.5kg/ha	22.5%	-0.07/yr
Offtake rate	33.1%	30.4%	43.8%	1.61/yr
Carcass weight	235.3kg	226.7kg	15.4%	0.81/yr
Carcass price/kg *	N$20.55	N$20.45	25.2%	N$0.55/yr
Labour cost / LSU *	N$210.9	N$193.3	34.7%	N$9.70/yr
Machinery cost / LSU *	N$236.4	N$217.1	32.3%	N$1.14/yr
Lick cost / LSU *	N$118.6	N$100.6	44.1%	N$27.4/yr
Maintenance cost /LSU*	N$236.4	N$217.1	32.3%	N$1.14/yr
Total variable cost / LSU*	N$668.5	N$608.8	31.4%	N$68.8/yr
Capital value of herd *	N$3.36 mil	N$3.22 mil	23.9%	-N$85.7/yr
Gross margin/hectare	N$10.76	N$10.10	199%	-N$0.17/yr

Source: Adapted from (Mopane, 2019).

Note: * denotes production costs which were deflated by the (Namibian Consumer price index, 2019).

The literature on the Namibian livestock sector shows that production is dependent on weather variables, while production and price variables have a lesser effect on production (Sartorius von Bach et al., 1992 and Sartorius von Bach and Kalundu, 2019a). Therefore, the weather variables were added to complement the production data, to augment the hypothesis that farmers require an early prediction and warning system (Winsemius, 2014, and Becker et al., 2014). Table 2 presents a descriptive summary of the selected weather variables. It is deduced from Table 1 that annual rainfall showed a declining trend with the highest variation. Meanwhile, the temperature is increasing, the ENSO shows an opposing average, tending towards an El Nino with a considerable variation. In their study of rainfall dynamics in Namibia, Sartorius von Bach and Kalundu (2019b) pointed out that the ENSO significantly affects the livestock production environment.

Table 2: Descriptive statistics of weather variables

Variable	Average	Median	CV	Slope
Annual rainfall	328mm	287mm	42.2%	-0.42/yr
Rainfall days per year	28.5	28.7	24.9%	-0.12/yr
ENSO *	-0.97	-1.60	706.1%	0.21/yr
Average temperature	21.1°C	21.1°C	1.6%	0.02/yr

Source: Adapted from (Mopane, 2019).

Note: The ENSO effect Kane (2009), was applied as a variable called the Southern Oscillation Index average (SOIA)

The gross margin per hectare (Table 1) showed a massive coefficient of variation. This is caused by the effect of drought in the past years. Figure 1 illustrates this high volatility in an arid environment to pinpoint to the huge coefficient of variation in gross margin for the production area under study.

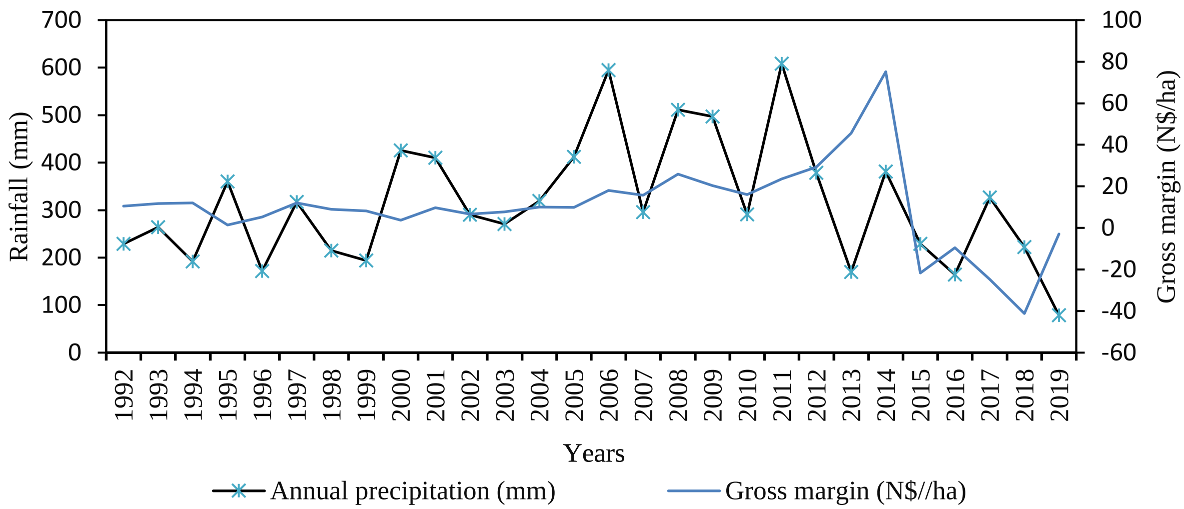

Figure 1: Gross margin and annual precipitation (1992 – 2019)

Source: Adapted from Mopane (2019)

In cases of low rainfall, the farmers had to adjust their herd size to the available pasture. Such a reduction of stock was more than the annual sales. The reduction of cattle stock resulted in the reduction of capital stock and eventually led to a reduction in the farmers' equity. It is clear that during the beginning of a drought cycle in 2013 and 2014, the gross margin per hectare was trending in the positive zone, however, as the drought impact persistent, the farmer's wealth declined steadily.

It is argued to utilize the above variables to explain their effects on the farmer's equity. It is argued, that farmers with access to knowledge will be more successful in building their net worth, which is the result of the accumulation of annual profits In case of improved access to knowledge, such as early warning on weather patterns, it is assumed that farmers could have adjusted their stock before the start of a drought period. It is known that during the drought stock prices reduced as a result of over-supply and worsening condition of the animal. Furthermore, this would have resulted in the reduction of feeding costs to the stock. Subsequently, during the anticipation of drought, farmers could therefore have improved gross margin per hectare. Figure 2 previews the different equity values.

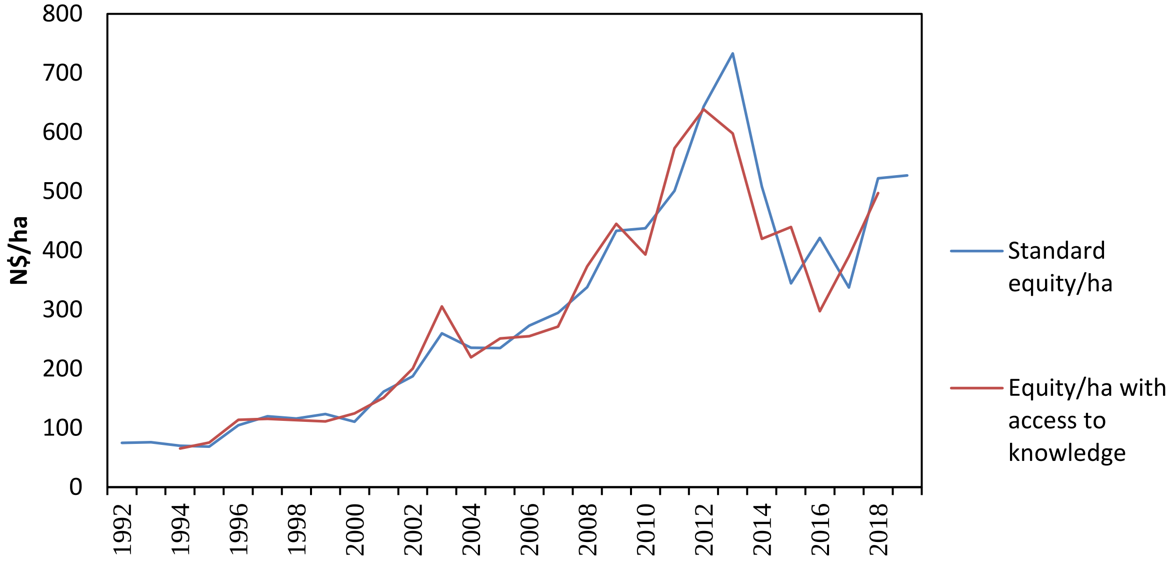

Figure 2: Comparison between the standard equity/ha and equity/ha as a result of access to knowledge
Source: Adjusted based on the annual dataset (1992 - 2019)

3.2. Empirical Model formulation

It is evident from the above description that two models are essential to demonstrate the influence of the farmer's decision process. The first model will estimate the net worth without prior knowledge of adverse climatic condition patterns. Where farmers have a void on information and are therefore reluctant to sell their cattle timeously before cattle lose their body condition and possibly die before the farmer can earn money from such cows. In summary, farmers are unable to adjust their cattle stock early enough to avert the impact of losses on the owner's net worth (see figure 1 and 2). Under this scenario, it is expected that the farmer will be forced to use part of the equity that he/she accumulated over the years of farming. Suppose there is continued lack of prior information. In that case, the farmer's obligation on the reliance on equity will continue to abate, and this may lead to pressure on the family farm income (FFI). The lack of information on the knowledge and technology for beef cattle production may result in passive decision making on the side of the farmer, and this may jeopardise the re-investment process in the farm operations (net worth without knowledge –NWHA).

On the contrary, the second model depicts the scenario where farmers receive all the relevant information and make all the necessary stock adjustment (net worth with knowledge-NWKHA) It is assumed here that because of the prior available information regarding the knowledge of the occurrence of adverse weather scenario for cattle production, the farmer has a complete decision process. The farmer will adjust the stock earlier, selling the right number of cattle at the appropriate time in order to cushion the net worth. The adjustment occurs by inducing a dynamic stock adjustment, which is achieved through the dynamic lag parameter in an autoregressive distributed lag.

3.2.1 Econometric models

This section starts by testing time-series properties using unit root tests. We then proceed to the estimation of the Ordinary Least Squares (OLS) and autoregressive distributed lag (ARDL). OLS assumptions are made concerning the regression model by following the Gauss-Markov assumption. ARDL evoke the lag structure, defined as the sizes of the coefficients of the current and lagged values of the explanatory variables. By definition, a variable X lagged at one time period has values that are simply the previous values of X, stated as X(-1). Testing for multicollinearity, it is required to ensure that point estimates are stable and standard errors are small. Therefore, a widely used formation of multicollinearity was employed as an autoregressive distributed lag model, often expressed as ARDL (p, q). The ARDL is parsimonious because it accommodates a broad range of dynamic pattern with few lag terms and parameters.

3.2.1.1 Unit root tests

The underlying traditional assumption when working with time series data is that it is stationary. This is important to avoid spurious regressions results and errant behaviour. It highlights the importance of unit roots; which applies to time series with a stochastic trend. A variable is said to be stationary if the mean; variance and autocovariance is constant, no matter at what point it is measured, meaning that it is independent of time (Maddala and Lahiri, 2009). Therefore, a series may have to be differenced several times in order to make it stationary. For brevity, in this paper, the Augmented Dickey-Fuller test (ADF) was employed to test for the presence of a unit root in the variables. The decision rule states that a variable is stationary if the ADF test statistic is greater than the critical value, and not stationary if otherwise.

3.2.1.2 Ordinary least Square approach

The next step was to develop two econometric models to answer the postulation emphasized in this study. The first model incorporates the association of deflated net worth per hectare to carcass price per kilogramme, herd size per hectare and Southern Oscillation Index average as formulated. The second model is based on the deflated net worth with knowledge per hectare. It was argued that the OLS approach is not sufficient to answer the postulation that in net worth with or without knowledge, contrary to (Dunn et al. 2010). This paper went further to explore the analysis in a more robust dynamic modelling framework. OLS approach is a precursor for underpinning a relationship that exists between net worth, herd size, carcass price and SOIA. Applying the concept of association, the OLS model was estimated to validate the claim that net worth with or without knowledge in the livestock production system is a function of herd size per hectare (HERD), carcass price per kilogramme (CARP) and SOIA. The assumptions are made about the regression model is that they follow the Gauss-Markov assumption. The nature of the general equation is formulated as:

$$Y_i = \beta_0 + \beta_1 + \beta_i X_{ti} X_t + \varepsilon_i \quad (1)$$

The dependent variable (NWHA or NWKHA as defined above) in Y_i (the dependent variable Y accounts for revenue and production cost. Production cost has been defined in this to include labour cost, machinery, lick cost, maintenance costs and variable costs) was assumed to be explained by the significant three exogenous variables (X_{ti}) denoting HERD, CARP and SOIA. β_0 and β_i, are parameters to be estimated, while ε_i is the disturbance term. The coefficient of each X_i variable provides an estimate of its influence on Y_i, controlling for the effects of all the other X_i variables (Maddala and Lahiri, 2009). Dependent variable Y is identically and independently distributed and independent from the ε_i term.

3.2.1.3 Autoregressive Distributed Lag

Since the OLS model is not able to validate the postulation of gross margin volatility as not being dynamic, the paper developed simple dynamic models. A dynamic model is based on the assumption that net worth in livestock production systems is primarily determined by current herd size per hectare (stocking rate), carcass price per kilogram and national oscillation index – a proxy for the rainfall patterns, and others. The paper considers a specification in which the net worth with knowledge or without knowledge depends on lagged values of prior information and the adjustment thereof, cattle herd size per farm size, carcass price per kilogramme and SOIA. The lag structure is defined as the sizes of the coefficients of the current and lagged values of the explanatory variables. By definition, a variable X lagged at time period has values that are simply the previous values of X. Testing for multicollinearity, it is required to ensure that point estimates are stable and have smaller standard errors. Therefore, a widely used formation of multicollinearity was employed as an autoregressive distributed lag model, often expressed as ARDL (*p*, *q*) as suggested by (Dougherty, 2012; Maddala and Lahiri, 2009). The ARDL is parsimonious because it accommodates a broad range of dynamic pattern with few lag terms and parameters.

The following equation is a simple dynamic ARDL formulation of equation 1.

$$Y_i = \varphi + \sum_{i=1}^{P} \gamma_i Y_{t-i} + \sum_{j-1}^{k} \sum_{j1=n0}^{q_j} X'_{j,t-1} \beta_{j,i} + \varepsilon_t \sum_{i=1}^{P} \gamma_i Y_{t-i} + \sum_{j-1}^{k} \sum_{1=0}^{q_j} X'_{j,t-1} \beta_{j,i} + \varepsilon_t \qquad (2)$$

Where variable Y_i and X_i areas defined before, while, φ is positive and that X_i increases with time and that $|\gamma|$ and $|\beta|$ are less than a unit, and both are parameters to be estimated and ε_t is the disturbance term or residual.

3 Results and discussion

Table 3 reports the statistics for testing the existence of unit root, as discussed in section 3.2.1.1. On both series, the paper failed to reject the null hypothesis of the unit root; therefore, series were first differenced, and the Akaike Information Criterion (AIC) was used to select the lag length. Table 3 summary give results of ADF in levels and first difference and their respective critical values at 5 per cent. Testing for unit root, the terminology for the variables used are the deflated net worth value without knowledge per hectare (NWHA) or Net Worth with knowledge (NWKHA), cattle herd size per hectare (HERD), average beef carcass price per kilogramme (CARP) and Southern Oscillation Index average (SOIA). For brevity, we show the unit root result in significant variables

Table 3: Unit root results for testing the stationarity of variables included in the model

Series	ADF Test in Levels	Critical values at 5%	ADF in 1st difference	Critical values at 5%
NWHA	-1.080*	-2.976	-4.664**	-3.5950
HERD	-1.282*	-2.976	-6.045**	-3.5950
CARP	-2.566*	-2.976	-4.710**	3.5950
SOIA	-3.573	-2.976	-6.359**	-3.5950

Note: the AIC was used to choose the lags. * denotes values that are not significant at 5% and ** denotes significant at 5% level after taking first difference with a constant, linear trend.

Table 4 provides a summary of OLS results, as discussed in section 3.2.1.2. The results serve as proof for argument on the *a priori* expectations. The choice is consistent with economic theory, where it is argued that net worth value is a function of herd size per hectare, carcass price per kilogram and oscillation index average (a proxy of rainfall patterns). Herd size per hectare significantly impacts net worth without prior knowledge with about 1.627 per cent, while exhibiting the impact of 1.523 per cent on the net worth with prior knowledge. In comparison, carcass price per kilogramme increases net worth by 1.131 per cent when prior information is incorporated in the decision-making process at the farm level. The price elasticity of the two models is 0.60 and 0.70, respectively, which points out that improved access to knowledge allows for livestock price responsiveness of 10 per cent. This is a significant impact in a farm operation. The explanatory power of both models is square, at 89 per cent. Both models yield a robust F-statistics; meanwhile, the Durbin – Watson (DW) test for serial correlation indicate a value of less than 2 for the both OLS model.

Table 4: OLS estimated results based on Equation 1.

Net worth without knowledge equation		Net worth with knowledge equation	
Variables	Coefficients	Variables	Coefficients
Constant	-611.97	Constant	-517.177
HERD	1.627 (0.000)*	HERD	1.523 (0.000)*
CARP	10.997 (0.000)*	CARP	12.128 (0.000)*
SOIA	54.744 (0.049)*		
R-Squared	0.8951	R-Squared	0.8939
F-Stats	68.30 (0.000)	F-Stats	101.119 (0.000)
DW	1.43	DW	1.256

* denotes rejection of null hypothesis at 5% level. Numbers in parentheses represent probabilities.

Table 5 provides the post-estimation results on normality, heteroscedasticity and serial correlation on the residuals. It shows that there is normality (Test A) in the residuals. However, there is a concern on heteroskedastic (Test B) and serial correlation (Test C) in the residuals. Therefore, based on the summarised results in Tables 4 and 5, we evoke the use of applying a more robust dynamic and refined model to capture the dynamics detected in figure 1 and 2.

Table 5: Summary of residual tests on OLS model

A	B	C
0.663 [0.717]	13.873 [0.003]	11.752 [0.003]

Note: A = testing for normality, B = Test for heteroscedasticity and C = is the LM test for serial correlation.

Hence the formulation ARDL equation 2 to provide more robust results (Maddala & Lahiri, 2009). The results are summarised in Table 6. It shows that the net worth value is influenced by its own lagged variable (0.675), current year's carcass price (18.206) carcass price lagged one year (-17.271), carcass price lagged two years (5.367), current herd size (1.279), herd size lagged one year(-0.729) and southern oscillation index average (0.048). This is expected for livestock production because net worth depends on the accumulative herd size, price and rainfall patterns. For example, a reduction of herd size in the past years will reduce the net worth value by a magnitude of -0.729% in the current year. Its explanatory power of the

ADL is 96 per cent, and Durbin-Watson value is close to 2 indicates that the residuals are free from serial correlation. After running 64 models, the selected ARDL (1, 2, 1, 0) was based on the AIC.

Table 6: Summary of ARDL (1, 2, 1, 0) estimation results

Variables	Coefficients
NWHA(-1)	0.675 (0.007)*
CARP	18.206 (0.007)*
CARP(-1)	-17.271 (0.015)*
CARP(-2)	5.367 (0.322)**
HERD	1.279 (0.000)*
HERD(-1)	-0.729 (0.026)*
SOIA	56.117(0.048)*
Constant	310.623
Adjusted R-Squared	95.7%
F-Stats	80.721(0.000)
Durbin-Watson stat	1.7999

Note: 64 models were evaluated, and ARDL (1, 2, 1, 0) was selected using the Akaike information criterion (AIC). * denotes value significant at 5 % level, while ** denote values that are not significant at 5%, respectively

As shown in Table 3, all of the series are stationary after first difference; therefore, it is now appropriate to use the Box-Jenkins methodology to determine the values of *p* and *q* in the ARDL (*p, q*) process (Box-Jenkins, 1976 & Neusser, 2016). The AIC chose the values of p and q. The Portmanteau test was used to test the residuals for autocorrelation up to lag 12. Where autocorrelation was detected, the models were re-specified using the autocorrelation (ACF) and partial autocorrelation functions (PACF) for guidance (Dougherty, 2012; Maddala & Lahiri, 2009).

Although the difference between the equity values (see figure 3) are relatively small, their impact is significant. The analysis showed that production costs were not included in the models and therefore, not included in the list of drivers of profitability. The same occurs for some production variables, such as the calving percentage, the weaning mass, the offtake rate, and so on. However, since they are interlinked to the herd size, the finding holds that production practices in the Namibian arid areas contribute to profitability.

This analysis provides a scenario that despite lack of knowledge on information regarding oscillation of rainfall patterns, cattle farming in the northwestern parts of Namibia continued over time. The vulnerability of net worth or gross margin value depends on herd size per hectare, carcass price per kilogram and rainfall. However, it is imperative to note that livestock production has become a risky endeavour, especially in recent years, with its recurrence of drought. The impacts of drought were depicted in the years of negative gross margin, which derives the net worth of the farm operation. The impact of drought on herd stocking rate per hectare augmented by other factors is compounded in the hypothesis for net worth accumulation and profit maximisation. Without prior knowledge on rainfall patterns, the gross margin per ha declined into constant negative values, which does not correspond to profit maximisation. In the case of this study group, farmers continued to invest in their business by using accumulated savings and non-farm earning. It is argued that other farming objectives such as sentimental value and the survival of the breeding herd contributed towards the explanation of the negative gross margins, as implied by (Green and Shapiro, 1994).

3 Conclusions

The paper shows that variables presenting production costs were not included in the models and therefore excluded as drivers to profitability. However, the southern oscillation index average has a significant impact on the farmer's preparedness in the arid areas of north-western Namibia. Results confirm with O'Leary et al. (2018) that specific husbandry behaviour and practices do not warrant for inclusion in the modelling of net worth. However, this paper's findings on the OLS conform to the findings of Locke (2013) and Dunn et al. (2010) the continuation with further analysis utilizing dynamic modelling in this paper questions the findings of Locke (2013) and Dunn et al. (2010) and. By comparing the two models, efficiency benefits are observed in the case of the knowledge model. Specifically, the farmers with knowledge require smaller herd size to survive and are more price responsive.

The dimension of livestock profitability in arid and semi-arid areas of Namibia opens up a debate on future livestock production. It should be argued that continual reliance on accrued net worth is acceptable as it reflects the process of how farmers can adjust to the dynamics of supply conditions. However, the extent of this dependence and reliance calls for concern among farming communities. The current status quo of reduction in herd size shows that net worth per hectare cannot be cushioned by risk management strategies and require government intervention. Although the findings are based on a study group of 8 ox producing farmers, it is anticipated that the average Namibian ox producer's circumstance is maybe worse than the results of this study group. However, the impact of the findings shows that the livestock industry could gain from improved access to the knowledge required for production. The incremental gain in price elasticity because of improved access to knowledge is 10 per cent allows for livestock price responsiveness. Findings call for a need for the availability of early warning systems to cushion the impact of volatility in the livestock industry. Besides, ox production should move away from traditional decision making to advanced farming practices. This paper suggests that the interpretation of time series data requires the use of further dynamic models for livestock production to utilize advanced farming knowledge and technology in beef cattle farm decision making processes.

Acknowledgements

The authors would like to extend gratitude to the farmers in northwestern Namibia for providing a comprehensive annual dataset of their private farm operations.

Disclosure of conflict of interest

The authors declare not conflict of interest

References

Abid M., Schilling J., Scheffran J. & Zulfiqar F. 2016. Climate change vulnerability, adaptation and risk perceptions at farm level in Punjab, Pakistan, *Science of the Total Environment*, 547, 447-460

Asplund, T., Neset, T.S., Käyhkö, J., Wiréhn, L. & Juhola, S. 2019. Benefits and challenges of serious gaming: The case of "The Maladaptation Game" https://doi.org/10.1515/opag-2019-0010

Becker, E.,van den Dool, H. & Zhang,Q. 2014. Predictability and forecast skill in NMME. *Journal of Climate*, 27, 5891–5906.

Bollerslev T. 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, 31(3), 307–327.

Box G.E.P & Jenkins G.M. 1976. *Time series analysis: forecasting and control* (Revised Edition). San Francisco, CA: Holden Day.

Dougherty, C. 2012. *Introduction to Econometrics*. 4th edition. Oxford University Press, New York

Dunn, B.H., Smart, A.J., Gates, R.N., Johnson, P.S., Beutler, M.K., Diersen, M.A. & Janssen, L.L. 2010. Long-term production and profitability from grazing cattle in the Northern mixed grass prairie. *Rangeland Ecology & Management.* 63(2) 233-242.

Kane, R.P. 2009. Periodicities, ENSO effects and trends of some South African rainfall series: an update. *South African Journal of Science*. 105, 199-207

Locke, I. 2013. *Moving towards a more sustainable beef production system*. Paper presented at Adams Stockmans School, Ventersdorp, RSA

Maddala, C.S. & Lahiri, K. 2009. *Introduction to Econometrics*, 4th edition. John Wiley & Son, Ltd. United Kingdom.

Meat Board of Namibia. 2019. *Annual Report*. Windhoek, Namibia

Monk, M.J., Jordaan, H. & Grove F.B. 2010. Factors affecting the price volatility of July futures contracts for white maize in RSA. *Agrekon* 49(4) 446-458.

Mopane. 2019. Study group annual statistics from 1992 until 2019, and earlier rainfall data, Namibia

Murray-Prior, R.B. & Wright, V.E. 2001. Influence of strategies and heuristics on farmers' response to change under uncertainty. *The Australian Journal of Agricultural and Resource Economics*, 45, 573-598.

Namibia Statistical Agency. 2019. *Namibia Consumer price index*, official statistics, NSA, Windhoek.

NAU (2020) Namibia Agricultural Union, data basis, Windhoek

Neusser, K. 2016. *Time series econometrics*, Springer. New York

O'Connor D. & Keane M. 2011. Empirical Issues Relating to Dairy Commodity Price Volatility, Chapter 5 p 63-83 in *Methods to analyse agricultural commodity price volatility*, eds Piot-Lepetit, I. & M'Barek R. ISBN 978-1-4419-7633-8.

O'Leary, N.W., Bennett, R.M., Trauter, R.L. & Jones, P.J. 2018. The extent that certain farmer attributes and behaviours are associated with business profitability. *Journal of Dairy Science*. 101(12) 1275 -84.

Sartorius von Bach, H.J., Van Zyl, J. & Vink, N. 1991. An empirical analysis of the role of prices and access to markets on beef numbers in Namibia: A regional approach. *Quarterly Journal of International Agriculture* 30(3): 224-235.

Sartorius von Bach, H.J. &Kalundu, K. M. 2019a. *An econometric estimation of gross margin volatility: A case of ox production in Namibia*. Paper presented at the 57th Agricultural Economists Association of South Africa (AEASA) 8 - 10 October 2019, Bloemfontein, South Africa.

Sartorius von Bach, H.J. &Kalundu, K.M. 2019b. *Estimating the Rainfall Patterns in Namibia: Are rainfall patterns a myth or fact?* Working paper, Department of Agricultural Economics, University of Namibia, Windhoek.

Ubilava, D. 2017. The ENSO effect and asymmetries in wheat price dynamics. *World Developmen*t 96, 490-502.

Qushin, B., Gillespie, J.M., Bhandari, B.D & Scaglia, G. 2018. Technical and scale efficiencies of US grass-fed beef production. J*ournal of Agriculture and Applied Economics*. 50(3).

Winsemius, H.C., Dutra E., Engelbrecht, F.A., Van Garderen E.A., Wetterhall F., Pappenberger F & Werner M.G.F. 2014. The potential value of seasonal forecasts in a changing climate in southern Africa. *Hydrology Earth System Science*, 18, 1525–1538.