A COMPARATIVE ANALYSIS OF THE NEURAL NETWORKS AND VECTOR AUTOREGRESSIVE MODELS: USING ECONOMIC VARIABLES

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Abstract - The study conducted a comparative analysis of ANN and VAR models in modelling and forecasting foreign direct investment and unemployment of South Africa obtained from SARB. The study employed both MSE and MAE to assess the performance accuracy of the model(s). The results obtained shows that ANN is superior in modelling and forecasting foreign direct investment and unemployment rate of South Africa.

Keywords - Artificial Neural Networks, VAR, Error metrics

I. INTRODUCTION

Unemployment is a multi-dimensional phenomenon, an economic phenomenon showing disproportion in the economic activity. The investment prompts accomplishing a high rate of sustained economic growth in the national economy and attends to the issue of unemployment. That when unemployment rises, foreign investment falls. They are substitutes of each other. Investment is mostly ignored as a key variable behind the problem of high unemployment, despite a strong empirical association between investment and unemployment. Unemployment ratings and Investments are analyzed using modern statistical methods. The customary strategies frequently used by data analysts to express the flow and structure in monetary time series data incorporate the assumption of linearity, inciting the majority of the models neglecting to tackle the basic of general financial and economic data. Statistical modelling and forecasting methods satisfies numerous helpful parts other than simply being devices for creating future forecasts. These drawbacks provided nonlinear time series models with an edge over linear time series models in terms of modelling and forecasting economic and financial data. [7]conducteda comparative analysis of vector auto regression and time-delayed neural networks with regards to predicting stock market returns from malicious attack. It was found that the time-delayed neural network model serves as a corresponding way to deal with customary vector autoregressive analysis.

[4] applied both Vector Auto Regression (VAR) and Bayesian Vector Auto Regression (BVAR) for forecasting the Indian Rupee and US Dollar exchange rate. They then found that the BVAR outperforms VAR. They also observed that the forecast accuracy improves if they include the forward premium and volatility of capital flows. In the end NN outperformed VAR when forecasting the exchange rate of Indian rupee and US Dollar. [1] the paper exhibits a highly expandable approach to neural networks and examines the connection between classical econometric techniques. The study found the review of the literature indicated that the NN are generally more appropriate than linear models for the purpose of forecasting macroeconomics and financial variables. [5] analyzed the forecasting oil price varying and predicted future oil price by comparing the capability of VAR and NN. Neural networks, known as capable methods in modelling the modern and nonlinear designs associated with the data, are chosen to display extremely complex capacities. Thus, conventional models are linear and basically based on some solid presumptions and previously information of input data statistical distributions. Without a doubt NN would be capable in efficiently displaying the nonlinear structures associated in oil price, bringing about a more dependable, exact and certain model can be delivered to consider the transient information contained in the outside world.

They concluded that NN, joined with genetic calculation optimization techniques[8], could conceivably be utilized for constructing a more precise models for forecasting Euro inflation and are prescribed for future research. The outcomes continue to validate that an enhanced macroeconomic forecasts can be accomplished with the use of nonlinear NN. Lastly, the best models for the NN beat the customarily used linear ARIMA and VAR models in macroeconomic forecasting and are statistically superior to the others[2]. The study seeks to compare the predictive accuracy of two models (ANN and VAR) in modelling and forecasting unemployment and foreign investment. The paper is constructed as follows: methodology and analysis in section II. Whereas section III outlines the summary and discussions of the paper.

II. METHODOLOGY AND ANALYSIS

In this section forecasting methods are introduced which are both neural network (NN) and vector autoregressive (VAR) respectively. Appropriate

model assessment(s) are also undertaken. Appropriate tests of the VAR model will also be assessed.

A. Vector autoregression (VAR)

Quarterly time series data of foreign direct investment and unemployment of South Africa is used in the study covering the period from 1994 to 2016. The series of FDI has an upward trend with some fluctuations and unemployment rate of South Africa is constant in the zero line of the graph. Figure 1 shows the plots of both series. As per recommendation the data must be subjected to stability condition before the actual analysis can be undertaken. AR root test will be employed in assessing the condition of stability and based on the results reported by the AR root test, it is found that after first difference of the series the series is stable. The results will be reported in the appendix section.

An Impulse response function is said to trace the effect of a one-time shock to one of the innovations on current and future values of the dependent variables. The variable investment and unemployment to itself; result reveal that they are correlated to itself. Impulse response function is reported in the appendix section. The forecast error decomposition is the percentage of the variance of the error produced in forecasting a variable due to a particular shock at a given horizon. That is why the forecast error decomposition is like a partial R^2 for the forecast error, by forecast horizon, according to[9].

The variance decomposition indicates the amount of information each variable contributes to the other variables in the autoregression. It determines how much of the forecast error variance of each of the variables can be explained by the dependent shocks to the other variables. The results of the forecast error variance decomposition will be presented under the section of appendix. The results of the variance decomposition of investment standard error is continuously increasing, with investment and unemployment. Thus, the variance decomposition of unemployment standard error is increasing, with unemployment and investment.

Forecast Evaluation
Date: 10/24/17 Time: 10:28
Sample: 1994Q1 2016Q4
Included observations: 92

Variable	Inc. obs.	RMSE	MAE	MAPE	Theil
DINVEST	92	2744.737	2053.061	3124.494	0.679867
DUNEMPLOY	92	1.257206	0.824520	1348.171	0.917079

RMSE: Root Mean Square Error
MAE: Mean Absolute Error
MAPE: Mean Absolute Percentage Error
Theil: Theil inequality coefficient

Fig. 1: Forecast evaluation

In the above figure, the root mean square error has been used as a standard statistical metric to measure model performance and mean absolute error is another useful measure widely used in model evaluations [3].

The results above in regards to RMSE for investment is 2744.737 and unemployment is 1.257. Thus, the results above in regards to MAE for investment is 2053.061 and unemployment is 0.8245.

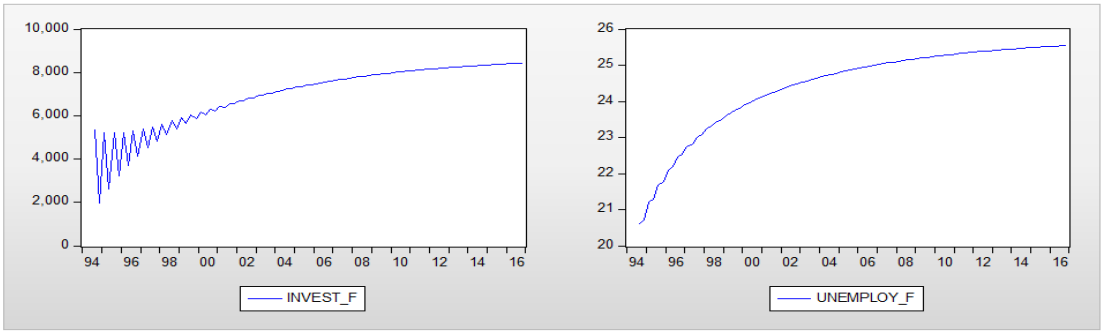


Fig. 2: Forecasts

The forecast above clearly indicates that for both investment and unemployment, there is an increasing trend. The increasing trend for investment is beneficial to the growth of the country but the trend has a negative impact on the country in regards to unemployment rising.

B. Artificial neural networks (ANNs)

Artificial neural network (ANN) are an attempt to model the information processing of neurons systems. Dr Robert Hecht-Nielsen defines a neural network as a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response external inputs. An artificial neural network (ANN) is basically a nonparametric attempt to model the human brain. In addition, ANNs are adjustable computing frameworks for modelling a wide scope of nonlinear issues. Their main strength is their adaptable nonlinear modeling ability. Their control originates from the parallel preparation of the information from the data. No previous theory of the model format is needed in the model building process. Instead, the network model will be generally confirmed by the qualities of the information. [10]however, adds that a single hidden layer

feedforward network is the most utilized model structure for time series modelling and forecasting. The output (y_t) and the inputs $(y_{t-1}, \dots, y_{t-p})$has a relationship that can be denoted as follows in a mathematical representation:

$$y_t = w_0 + \sum_{j=1}^{q} w_j \cdot g\left(w_{0j} + \sum_{i=1}^{p} w_{ij} \cdot y_{t-i}\right) + \varepsilon_t (1)$$

given that $w_{ij}(i = 0,1,2,\dots,p, j = 1,2,\dots,q)$ and $w_j(j = 0,1,2,\dots,q)$ are model parameters often called connection weights; p is the number of inputs nodes; and q is the number of hidden nodes. The Bipolar sigmoid function is often used as the hidden layer transfer function, that is,

$$\text{Tanh}(y) = \frac{1-\exp(-2y)}{1+\exp(-2y)}. \quad (2)$$

Such that the ANN model in (1), a nonlinear function mapping will be performed from the past observations to the future valuey_t, i.e.

$$y_t = f(y_{t-1}, \dots, y_{t-p}, w) + \varepsilon_t \quad (3)$$

given that w is a vector of all parameters and $f(\cdot)$ is a function determined by the network structure and connection weights. Thus, the neural network is equal to a nonlinear auto-regression model. Table Ipresents the assessment of performance measures (Error, MSE and MAE) with various input variables, hidden layer(s) and the number of training on the testing set for Investment and Unemployment. Training for each network is between 1000 and 10 000 iterations withincrements of 1000. The Bipolar sigmoid activation function is used in the study. Transfer function, for example, the bipolar sigmoid are generally utilized for time series information since they are nonlinear and persistently differentiable, which are attractive properties for network learning [6]. The best model of feed forward NN was found after the vital training of the network at various hidden layer(s) that brought about the lowest error. Besides, the examination selected the network which comprises one input layer, two hidden layers and one output layer at a learning rate, momentum and maximum iterations of 0.01, 0.1 and 50 000 for investment and at a learning rate, momentum and maximum of 0.03, 0.3 and 30 000 for unemployment respectively. The model is used for in sample forecasting. When ANN is utilized the accuracy of forecasting improves as the number of iterations increases.

Table I: In sample forecasting results

Activation Function: Bipolar Sigmoid			
	Error Matrics		
Variables	Error	MAE	MSE
Investment	1.32702	0.02797	0.00877
Unemployment	1.42039	0.02475	0.00933

CONCLUSION

In accomplishing this objective, the two models were assessed. The stationary presumption of the data was at the centre of the estimation of the models. The stationarity was obtained after the first differencing of the data. The continuation of the VAR model is based on the stability of the model using the AR root table, which has been satisfied. The design technique of the ANN was the feed-forward which comprises of three layers. The activation function used was the bipolar sigmoid function. The number of trainings are between 1 000 and 10 000 with increment of 1 000. Hence after the training the best ANN is on one input layer, two hidden layers and one output layer at a learning rate, momentum and maximumiterations of 0.01, 0.1 and 50 000 for investment and at a learning rate, momentum and maximum of 0.03, 0.3 and 30 000 for unemployment respectively. To compare the predictive power, the three error matrices were used and are as follows: MSE, MAE and Error respectively. The VAR predictive power was found to be the best as the values of the error metrics for one of the variables was robust and the other approximately half of the ANN. These results obtained have shown that the ANN model has outperformed the VAR model.

Appendix

Appendix I

Table II: VAR impulse response function

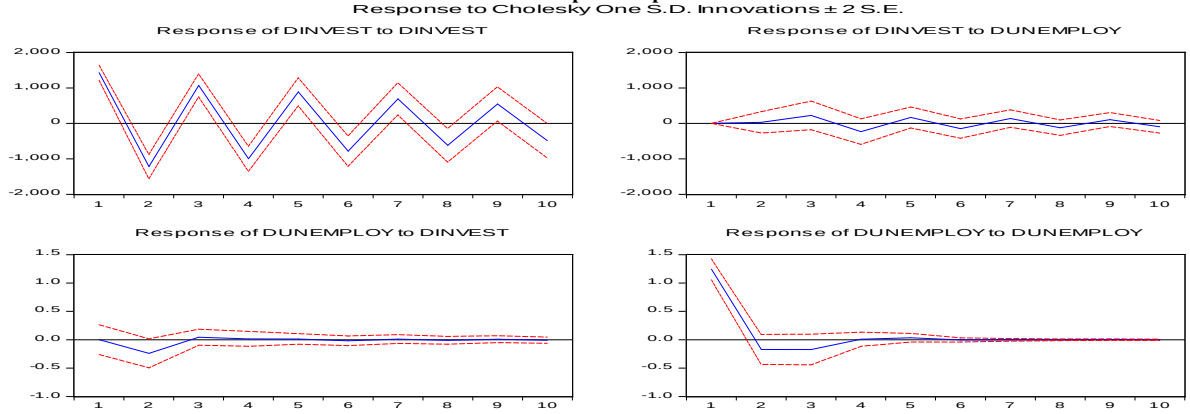


Table III: VAR variance decomposition

Variance Decomposition of DINVEST:			
Period	S.E.	DINVEST	DUNEMPLOY
1	1431.906	100.0000	0.000000
2	1879.357	99.97478	0.025217
3	2175.397	98.89809	1.101906
4	2403.785	98.17415	1.825851
5	2568.223	97.97433	2.025670
6	2688.595	97.85309	2.146913
7	2780.003	97.74972	2.250281
8	2850.190	97.67775	2.322254
9	2904.236	97.62842	2.371576
10	2946.081	97.59187	2.408127
Variance Decomposition of DUNEMPLOY:			
Period	S.E.	DINVEST	DUNEMPLOY
1	1.242260	0.000125	99.99987
2	1.276841	3.539395	96.46060
3	1.289308	3.588559	96.41144
4	1.289425	3.601732	96.39827
5	1.289943	3.610224	96.38978
6	1.290087	3.631257	96.36874
7	1.290145	3.639488	96.36051
8	1.290184	3.644953	96.35505
9	1.290222	3.650166	96.34983
10	1.290251	3.654370	96.34563
Cholesky Ordering: DINVEST DUNEMPLOY			

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