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Analyzing the Suitability of the Spline models and other forecasting Models in the estimation of Cassava Production in Nigeria.

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Abstract:

This research lay emphasis on which model among the polynomial or spline models (spline with knots and spline without knots), linear, semi-log and growth models best fit in forecasting cassava hectarage and output in Nigeria using time series data from 1961 to 2014. The models were evaluated using historical trace path of the observed data, level of the significant estimates, R-square values, turning points and Mean Absolute Percentage Error (MAPE). The study showed that spline model with knots and spline model without knots were appropriate for predicting future estimates of cassava hectarage and production in Nigeria. The models best traced the observed data path more accurately, having more significant estimates, largest R-square values, high number of turning points and have the lowest MAPE. The forecast values of both area and production depicted increasing trend. The results show that by year 2035, the cassava hectarage will be about 12, millions hectares and output of about 110 million tones. Since most of the cassava produced is consumed locally in the country, this will help in policy formulation with regards to cassava production in Nigeria. It provides a good vision of food security with extremely increasing population and scarce available resources. r.studio packages was used in the analysis. R studio version 1.1.383 (R studio team 2016).

Key words: spline models, forecasting, cassava hectarage and output

INTRODUCTION

Many development oriented policies have been implemented in Nigeria, especially in the agricultural sector since independence. The Federal Government has made some institutional and policy reforms targeted at improving the socio-economic status of the smallholder cassava farmers. This includes Root and Tuber Expansion Programme (RTEP) is an offshoot of the Cassava Multiplication Programme. The RTEP is a farmer oriented programme whose beneficiaries are poor households and smallholder farmers but the overall objective of RTEP is to enhance national food self-sufficiency, improve rural households' food security and income for poor farmers within the cassava producing States of Nigeria (eke-okoro, O.N. and Njoku, D.N. 2012).

Nigeria was a major cassava producing country ranking fourth in the World after Brazil, Zaire and Indonesia in the 18^{th} Century and later part of the 19^{th} Century, Central Bank of Nigeria (CBN, 2005). However, today, Nigeria is the largest producer of cassava in the World with an annual estimate of 54.8 million metric tons, 7.1 million hectares cultivated and yield of 77,203 kg/ha, Food and Agricultural Organisation Statistical Database (FAOSTAT), 2015). The country has consistently been ranked as the world's largest producer of cassava since 2005, (FAO, 2012).

Grafted polynomial (spline) models are used in econometrics to embark on economic analysis involving time series. It was assumed that different functional forms may fit different segments of a time series or response studies. Segments of polynomials can be used to approximate production surfaces or frontiers and to forecast time series. The segment to be used to forecast time series as in trend studies must end in a linear form. These segmented curves are restricted to be continuous and differentiable at the joined points, (Odedukun, *et.al.*, 2015).

Badmus and Ariyo (2011), used Auto Regressive Integrated Moving Average (ARIMA) model to analyse maize projection in Nigeria. Their findings showed that maize production for the year 2020 will be 13425.64 tons. Suleiman and Sarpong, (2012), employed the Box-Jenkins approach to model milled rice production in Ghana using time series data from 1960 to 2010. Although, a ten years forecast with the model shows an increasing trend in production, the forecast value at 2015 (283.16 thousand metric tons) was not good enough to compare with the 2012 rice production of Nigeria (2700 thousand metric tons), the leading producer of rice in West Africa.
Nmadu, *et al., (*2009), tested the possibility of the type of spline function and joint points selected affecting the consistency of the ex-post and ex-ante forecasts using cereal production (1961-2006) and percent contribution of agriculture to GDP (1961-2004) in Nigeria. The researchers used three types of model, that is, Linear-Quadratic-Linear, Quadratic-Quadratic-Linear and Linear-Quadratic-Quadratic. The researchers concluded that there is no universality as to which model is appropriate, rather all possible models should be tried and the one that gives most consistent result when compared to observed data and other factors should be used.

MATERIALS AND METHOD

For the purpose of forecasting of hectarage and production of cassava, the study has used the long range of annual time series data. The data set covers almost all history of Nigeria and it ranges from 1961 to 2014. The data has been collected from various statistical supplements of Agriculture Statistics of Nigeria published by Nigerian Bureau of

Statistics (NBS) and Food and Agricultural Organisation statistical bulletin (FAOSTAT). Keeping in view the aims of the study and nature of statistical information, various methods of forecasting have been considered at the time of data analysis. The objective of the research is to develop models that can accurately and effectively forecast the area, yield and output of cassava in Nigeria.

The accuracy and suitability of the polynomial models (spline with knots, spline without knots), linear, semi-log and growth models is evaluated using historical trace path of the observed data, level of the significant estimates, R-square values, turning points and Mean Absolute Percentage Error (MAPE),which can be calculated as follows:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right| \times 100 \text{-----------------(1)}$$

A_t = actual value of the variables of the interest in period t

F_t = forecast for period t

t = period at consideration

n = total number of periods

r.studio packages was used in the analysis. R studio version 1.1.383 (R studio team 2016).

RESULTS AND DIXCUSSION

The results of which model is suitable for forecasting hectarage and output of cassava in Nigeria is presented in this section. Figure 1, shows the historical path of the hectarage data. It was observed that the polynomials spline models with and without joint (knots) points better traces the historical path of the hectarage data while the linear and semi log models are completely out of place, they are at variance with the observed data which means they cannot give the best result for forecasting cassava hectarage. The goodness fit properties of the five models as shown in table 1 indicated that the splines with and without knots gave the best results. The R^2 values of 96% and 90% for splines with and without knots respectively obtained are very high. Similarly, these models have the highest number of turning points and the lowest mean absolute percentage error (MAPE) of 12% and 9% respectively compare to the linear, semi-log and growth models that has MAPE of 31%, 53% and 100% respectively. Table 2 also shows that the spline models with and without knots have the highest significant values compare to linear, semi-log and growth models. Similarly, the results of which model is suitable for forecasting cassava output in Nigeria is presented in figure 3, polynomials spline models with and without joint (knots) points clustered towards the output data while the linear and semi log models moves away from output observed data. Table 3 also shows the R^2 values of 97% and 96% for splines with and without knots respectively which is also higher than other models. Similarly, these polynomial spline models have the highest number of turning points (14 and 18 turning points respectively) while all other models have 11 turning points and the lowest mean absolute percentage error (MAPE) of 13% and 9.9% respectively compare to the linear, semi-log and growth models that has MAPE of 28%, 53% and 100% respectively. Table 4 also shows that the spline models with and without knots have the highest significant values although linear, semi-log and growth models are also significant.

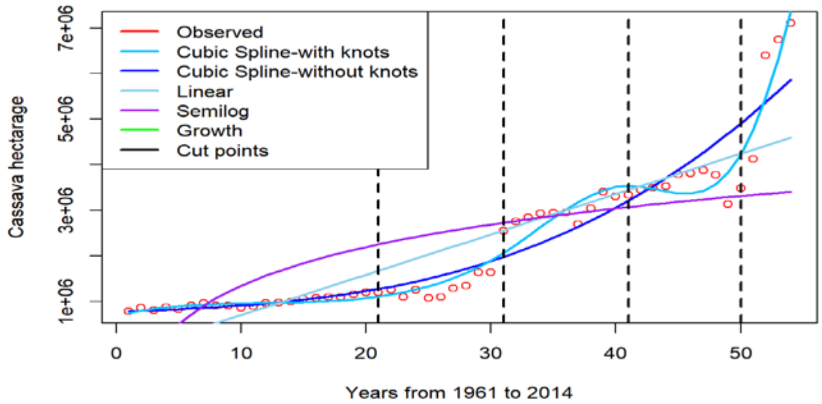

figure 1: Cassava hectarage 1961 to 2014 showing the tracing path of the models.

Table 1: Goodness of fit properties of the models for forecasting cassava hectarage

Variables	Spline with knots	Spline without knots	Linear	Semi-log	Growth
R-Square	0.962	0.896	0.786	0.486	0.915
Turning points	13.00	18.00	13.00	13.00	13.00
MAPE	12.000	9.000	31.000	53.000	100.0

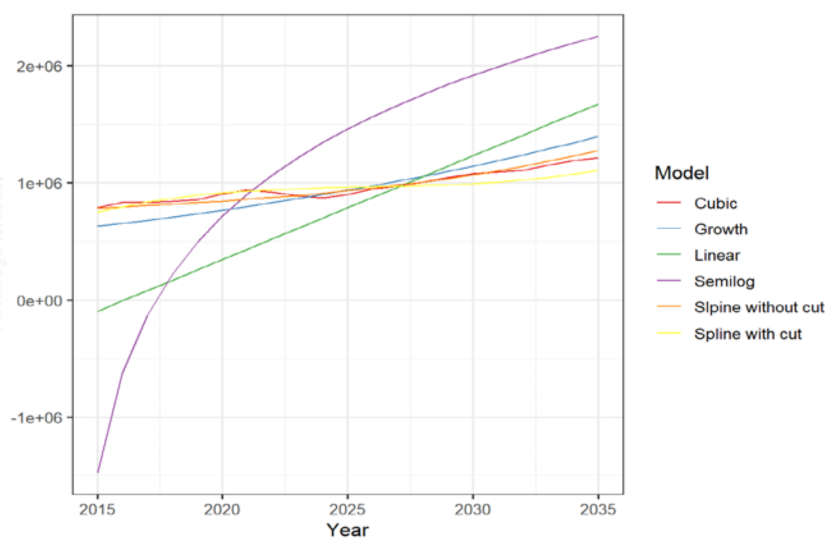

Figure 2: cassava hectarage forecast

Table 2: Estimates of the forecasting models for cassava hectarage

Variable	**Spline without Knots**	**Spline with Knots**	**Linear**	**Semilog**	**Growth**
	(1)	(2)	(3)	(4)	(5)
(Intercept)	78.445 **	74.988**	-18.615	-147.788 *	13.311 ***
	(2.644)	(2.184)	(2.022)	(5.537)	(0.053)
bs(niz[, 1], knots = NULL)1	19.029				
	(7.707)				
bs(niz[, 1], knots = NULL)2	50.266				
	(5.043)				
bs(niz[, 1], knots = NULL)3	50876 ***				
	(4.125)				
bs(niz[, 1], knots = c(21, 31, 41, 50))1		34.046			
		(4.836)			
bs(niz[, 1], knots = c(21, 31, 41, 50))2		-13.720			
		(3.172)			
bs(niz[, 1], knots = c(21, 31, 41, 50))3		98.652 **			
		(3.516)			
bs(niz[, 1], knots = c(21, 31, 41, 50))4		359.573 ***			
		(3.388)			
bs(niz[, 1], knots = c(21, 31, 41, 50))5		175.938 ***			
		(4.093)			
bs(niz[, 1], knots = c(21, 31, 41, 50))6		514.363***			
		(3.964)			
bs(niz[, 1], knots = c(21, 31, 41, 50))7		662.429 ***			
		(3.797)			
niz[, 1]			88.599***		0.039 ***
			(6.397)		(0.001)
log(niz[, 1])				122.519 ***	
				(1.747)	
N	54	54	54	54	54
R2	0.896	0.962	0.786	0.486	0.915
Log Likelihood	-785.273	-757.686	-804.845	-828.593	13.167
AIC	1580.546	1533.372	1615.691	1663.186	-20.335

*** p < 0.001; ** p < 0.01; * p <0.05 **source: research survey, 2019.**

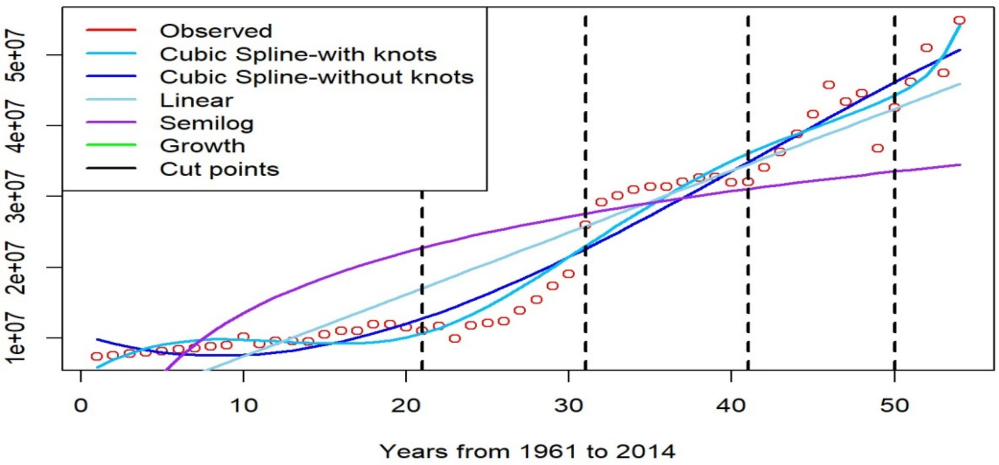

Figure 3: **Cassava output 1961 to 2014 showing the tracing path of the models.**

Source: research survey, 2019.

Table 3: Goodness of fit properties of the models for forecasting cassava output

Variables	Spline with knots	Spline without knots	Linear	Semi-log	Growth
R-Square	0.972	0.960	0.893	0.583	0.939
Turning points	14.00	18.00	11.00	11.00	11.00
MAPE	13.000	9.900	28.000	53.000	100.00

Source: research survey, 2019

Table 4: Estimates of the models for cassava output in Nigeria.

Variable	**Spline without Knots**	**Spline with Knots**	**Linear**	**Semilog**	**Growth**
	(1)	(2)	(3)	(4)	(5)
(Intercept)	98.223 ***	58.478 **	-12.802	-15.039 **	15.596 ***
	(1.504)	(1.723)	(1.321)	(4.611)	(0.045)
bs(niz[, 1], knots = NULL)1	-11.230 *				
	(4.384)				
bs(niz[, 1], knots = NULL)2	21.433 ***				
	(2.869)				
bs(niz[, 1], knots = NULL)3	40.921 ***				
	(2.346)				
bs(niz[, 1], knots = c(21, 31, 41, 50))1		82.197 *			
		(3.815)			
bs(niz[, 1], knots = c(21, 31, 41, 50))2		-33.999			
		(2.503)			
bs(niz[, 1], knots = c(21, 31, 41, 50))3		17.385 ***			
		(2.774)			
bs(niz[, 1], knots = c(21, 31, 41, 50))4		31.103 ***			
		(2.673)			
bs(niz[, 1], knots = c(21, 31, 41, 50))5		36.101 ***			

Variable	Spline without Knots	Spline with Knots	Linear	Semilog	Growth
		(3.229)			
bs(niz[, 1], knots = c(21, 31, 41, 50))6		41.511 ***			
		(3.128)			
bs(niz[, 1], knots = c(21, 31, 41, 50))7		4837 ***			
		(2.995)			
niz[, 1]			87.375 ***		0.041 ***
			(4.181)		(0.001)
log(niz[, 1])				12.418 ***	
				(1.456)	
N	54	54	54	54	54
R2	0.960	0.972	0.893	0.583	0.939
Log Likelihood	-879.154	-869.225	-906.227	-943.090	21.406
AIC	1768.309	1756.451	1818.454	1892.181	-36.812

*** p < 0.001; ** p < 0.01; * p < 0.05.

Source: research survey, 2019.

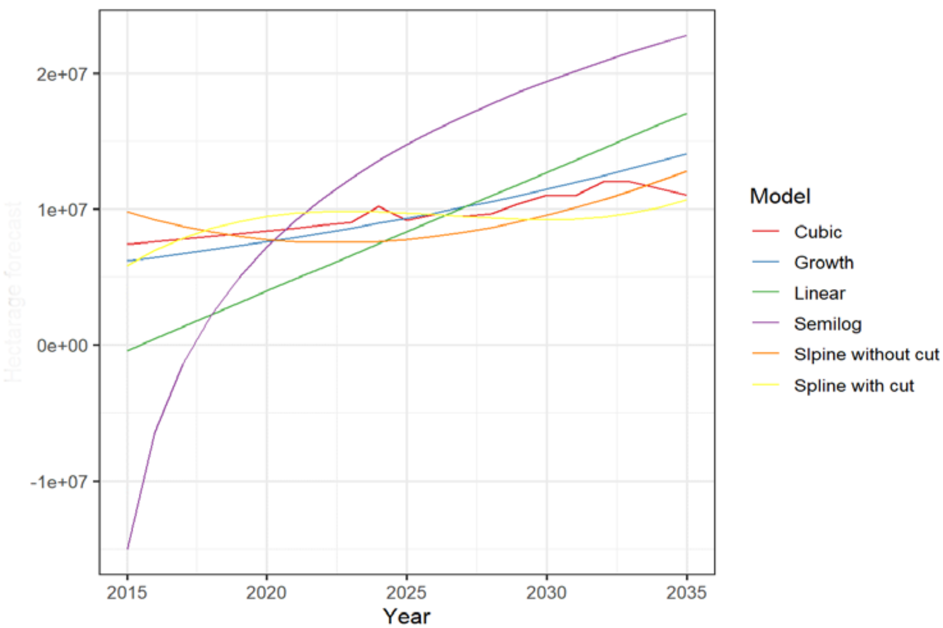

Figure 4: cassava output forecast

Conclusion and recommendations

The study concludes that the best model for forecasting cassava hectarage and production in Nigeria are the polynomial or spline models (spline model with knots and spline model without knots). This result is in contrast to the study conducted by Nmadu, *et al., (*2009), that there is no universality as to which model is appropriate, rather all possible models should be tried and the one that gives most consistent result when compared to observed data and other factors should be used. The projection of cassava hectarage and production from 2015to 2035 shows increasing trend, this in line with the findings of Dilshad, A., *et al.*, *(*2017). The cassava forecast for hectarage and production for 2035 in Nigeria was estimated around 12 million hectares and 110 million tonnes respectively. The policy makers, private sector and the farmers can effectively and accurately use the results of this study to manage and plan appropriately the production of cassava in Nigeria. Since most of the cassava produced in Nigeria is consumed locally, it is advisable to focus attention on mass production that equally enables mass exportation of cassava products. This will earn the country foreign exchange and will also address the issue of food insecurity in the country.

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