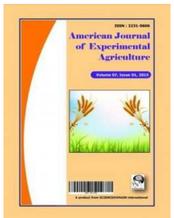

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Econometric Analysis of the Economic Cost of Lethal Yellowing Disease (LYD) on Coconut (*Cocos nucifera* L.) Yield in LYD Epidemic Area of Nigeria: A Case Study of Nigerian Institute for Oil Palm Research (NIFOR)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Coconut is cultivated particularly in the Southern part of Nigeria mostly as economic crop. However, in recent years its production has been declining due to lethal yellowing disease (LYD). This poses a threat to coconut and its industry, and consequently to coconut growers in LYD epidemic zones. This study is aimed at ascertaining the economic cost of lethal yellowing disease

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on coconut (*Cocos nucifera*) yield in LYD epidemic zones in Nigeria. Data spanning 10 years, from 2000 to 2010 obtained from the records of Plant Breeding Division, Nigerian Institute for Oil Palm Research (NIFOR) Benin City, Edo State were used for this study. Ordinary least squares (OLS) method was employed. The software used for analysis was Eviews7. Results obtained from the regression of the data indicate that expected annual yield of diseased palms (EAYDP) and price per unit nut (PUN) are significant determinants of economic cost of coconut production in the area and that LYD is a major threat to coconut production. It is recommended that preventive and control measures should be taken to reduce the incidence of LYD in epidemic zones.

Keywords: Coconut; lethal yellowing disease; economic cost; NIFOR.

1. INTRODUCTION

Agriculture is a major sector of the Nigerian economy, providing employment for about 70% of the population mainly in rural communities and accounts for over a quarter of the national Gross Domestic Product (GDP). The palms industry constitutes a significant part of the agricultural sector of the economy. It provides food and raw materials for the social confectionery, personal care products industry and employment. The palm family includes oil palm, coconut palm, raphia palm and date palm. Rural communities in South-East, South-South, and parts of South-West and Middle belt regions of Nigeria depend on the palm industry for their livelihood. The coconut palm is an important economic crop in these parts of the country.

Coconut palm, *Cocos nucifera* L, otherwise known as the ‘tree of life’ because of its versatility as seen in its many uses, is a valuable domestic and export commodity. The coconut grove plantations in the country are estimated at 13,615 ha with over 2 million coconut trees providing livelihood for over 30,000 rural families for whom coconut is a source of food, income, wood fuel, building material, and drink [1].

The term coconut can refer to the entire coconut palm. It is derived from the word *coco* in Portuguese and Spanish, meaning “head” or “ skull”, from the three indentations on the coconut shell that resemble the facial features of a pair of eyes and the nose. It is successfully grown in the tropic and sub-tropic areas, hence referred to as ‘king of the tropical palms’. There are different coconut varieties and they are divided into two major groups, the ‘tall’ and ‘dwarf’ varieties. Both cultivars can hybridize to produce intermediate forms [2]. Coconut varieties include the West African tall, dwarf green, Malayan dwarf yellow, Malayan dwarf red and hybrid coconut. They are named after areas where they have been grown long enough to have developed distinctive characteristics associated with these areas.

Every part of the coconut palm, from the roots to the leaf crown, is useful and many value added products are derived from them. It is regarded as one of the most important plants to humans around the world particularly in Nigeria where the coconut tree is planted as a mark of human birth. The tradition is still being practised in some rural areas of the country. The nut or meat is a source of food, provides a nutritious supplement for body fluids and minerals, mainly potassium. The liquid endosperm is also a medium for *in-vitro* storage of seeds and it is a growth regulator of plants [3]. Copra, the dehydrated meal or endosperm of the nut is a source of oil also used in premium cosmetics and pharmaceutical industries. The material that remains after the oil is extracted from copra is called coconut cake or meal and is used as animal feed. Coconut shell is used directly as fuel, filler, and extender in the synthesis of plastics and produces activated charcoal, household articles and various distillation products such as tar, wood-spirit and pitch. Coir, a coarse fibre from the husk of the nut has various domestic and industrial uses. Coconut root is brewed and used in folk medicine, for example, as a cure for dysentery. The agro-forestry uses of coconut palm include coastal stabilization and windbreaks. It also contributes to aesthetic landscapes, home beautification and shading for both tourists and locals; and provides employment and income for coconut farmers. The economies of several nations are mainly dependent on their coconut industries.

It is, however, observed that there has been a decline in productivity of coconut due to biological, social and economic constraints. Of these, LYD seems the most serious because of the direct damage it inflicts on plantations and also the uncertainty and loss of confidence in investment in replanting and rejuvenation of the large extensions of older palms [4]. Indeed, in recent years, coconut cultivation has encountered a strong phytopathologic constraint generated by the LYD [5].

The problem of lethal yellowing disease dates back to over a century in the Caribbean where devastating epidemic outbreaks of lethal yellowing disease occurred after the second world war. It has spread all over the Caribbean region, including Cuba, the Bahamas, Haiti, the Dominican Republic, Mexico, Florida, and Texas [6].

Lethal yellowing disease also extended to the African continent. The first reliable reference to this disease in Tanzania was in 1905. A few early outbreaks were reported in the first two decades of the 20th century in the Kisarawe, Rufiji and Kilwa districts. Lasting outbreaks were not reported before the 1940s when the modest early groves had been greatly expanded. It occurs in almost the entire coastal coconut belt of mainland Tanzania but tends to be absent or less active in groves further inland [7]. Since 1988 it has also been observed on the Island of Mafia near the Tanzanian coast. In Mexico, in 1982, the first affected coconut palms were observed in Cancun and Isla Mujeres, from where it spread along the coast to Yucatan, Chizen Itza and Telchac. The first cases have also been observed in the city of Merida country.

According to [8], LYD was first reported in Nigeria in 1917 as Awka Wilt at Akwa in the former Eastern Region, now Anambra State and over 5,000 diseased palms were destroyed in the course of the epidemic. The disease spreads fast: - a velocity of 50km per year has been estimated and this may have enormous economic consequences for the country affected [9] where it has destroyed millions of coconut palms.

The destructive nature of LYD on this multi-purpose palm is, therefore, of great concern to coconut farmers. Its potential to eradicate the coconut palms threatens the economy of affected area [10]. Hence the need to ascertain the economic cost of the impact of LYD on coconut yields in the disease epidemic zones of Nigeria. To the best of our knowledge, it was observed that there is an information gap in this area especially in the Nigerian agricultural sector. This research intends to bridge that gap by evaluating the economic cost of LYD on coconut yield in LYD epidemic areas of the country.

1.1 The Objectives of the Study

The general objective of this study is to: ascertain the economic cost of LYD on coconut yield in LYD epidemic zones of Nigeria.

The specific objectives of the study include

- to assess the effect of LYD on coconut yield and
- to determine the economic cost of LYD on coconut production

2. BRIEF LITERATURE REVIEW

Coconut, *Cocos nucifera* production is under the threat of lethal yellowing disease in epidemic zones of Nigeria. Studies have shown that LYD poses a great threat to coconut growing countries' economies. According to [11], lethal yellowing disease has destroyed several thousand hectares of coconut fields in its epidemic areas including Nigeria. Since 1980, the disease has gradually spread to Edo and Delta States. It has also spread to other parts of the country and was detected in a ten hectare coconut plantation in 1995 when a general survey was conducted [12]. In 2006, 98.8% of the West African tall (WAT) palms in the same plantation died, while 72% of the dwarf varieties were lost [13]. Further studies carried out in the country show that LYD destroyed many coconut palms in epidemic zones.

The disease was first observed in Ghana, a West African country (where it is also known as Cape St. Paul Wilt Disease) at Weh, near Keta, in 1932. By 1951, the epidemic had spread rapidly to the north-east of Keta and by 1970 the vast majority of palms in the Weh-Cape St. Paul and Tegbi areas had been destroyed. Lethal yellowing disease has caused the region to lose its status as one of the three major coconut growing regions in the country. For the remaining two major coconut growing regions in Ghana (Western and Central), the disease had devastated about 5,500 ha of coconut farms leading to economic hardships for thousands of farmers whose livelihood depends on the palm [14]. Also, about one million coconut palms were destroyed within 30 years [15]. The spread of the disease still continues.

Mozambique's coconut industry has been significantly affected by LYD, threatening the livelihoods of about 1.3 million people who depend on coconut as their main source of income and nutrition. The country was formerly one of the world's largest producers of coconuts. According to [16], Mozambique produced approximately 62,000 tons of copra, dried coconut meat, which was used for export, oil production, and local consumption. Reports estimate that as much as half of the country's coconut trees have been destroyed by LYD, making it impossible for the country to sustain the same level of production, export and income. The Zambezia and Nampula provinces are currently affected by LYD.

The disease destroyed about 300,000 coconut palms in Miami, Florida, USA in less than 5 years [17]; it invaded Key West, Florida in the 1930s and wiped out about 75% of the coconut palms before it subsided in 1965. It appeared in Key Largo in 1969 and on the Florida mainland, in Miami, in 1971. By 1973 it had spread northward along the east coast to Palm Beach County. In 1983, the epidemic had destroyed an estimated 100,000 coconut trees. In the late 1980s, lethal yellowing disease appeared on the South-Western coast of Florida on Estero Island near Fort Myers and remains highly active, killing many of the older coconut palms and palms of other species [18]. Lethal yellowing disease spread to Honduras in 1995 and destroyed 70% of the country's original population of coconut trees [19]. As reported by [20], coconut output from the Caribbean region declined from 504,877 tons in 2008 to 410,395 tons in 2009 as a result of storm damage as well as the wave of lethal yellowing disease.

It has also been observed that lethal yellowing disease affects other palms. Examples include *Caryota mitis* (clustering fishtail palm), *Dictyosperma album* (hurricane or princess palm), *Livistona chinensis* (Chinese fan palm), and *Trachycarpus fortunei* (windmill palm) [21].

On the whole, LYD has a devastating impact on coconut and incurs economic cost on growing countries' economies.

3. METHODOLOGY

3.1 Study Area

The study was carried out at the Nigerian Institute for Oil Palm Research (NIFOR) Main Station, Km 7, Benin-Akure Road, near Benin City, on a campus of 1735 ha. The institute, a research centre established in 1939, has enormous infrastructure developed over a period of about 75 years, comprising laboratories, office buildings, engineering workshops, library, oil mills, over three hundred units of residential houses and municipal services such as water supply scheme, electricity power generators, medical facilities and primary schools. The Institute's human resource consists of research scientists, laboratory and field technical support staff, administrative and accounting staff, library staff, health care workers, clerical and field labour. Currently, the Institute has staff strength of 1,704.

Research on coconut started in 1963 and a Coconut Research Substation was established in the main coconut growing area at Abia near Badagry, Lagos State in 1978.

3.2 Study Design

The study design employed is the degree of prevalence of various coconut varieties to LYD in Nigeria.

3.3 Duration of Study

The study reviews coconut production in NIFOR for the time period 2000 – 2010.

3.4 Data Collection

The data were obtained from the records of Plant Breeding Division, Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Edo State.

3.5 Data Analysis

Collected sample data were analyzed using Eviews 7 and Ordinary Least Squares (OLS) method was employed to estimate the model.

3.6 Model Specification

3.6.1 Model 1: Economic Cost (EC)

Suppose every coconut tree planted and tended survives and produces at its natural rate then the economic benefits of such a tree would be bountiful. But if such a tree is diseased then there would be loss in yield, in the tree population, in the expenditure of time and efforts for cultivation. In this study, the first model seeks to find out the cost of Expected Annual Yield of Diseased Palms (EAYDP), Price per Unit Nut (PUN) and the Ratio of Diseased Palms to Total Number of Palms (RDPTNP).

Economic cost in this study is hypothesized to be a function of EAYDP, PUN, and RDPTNP.

In mathematical form the hypothesized relationship may be written as follows:

$$EC=f\ (EAYDP, PUN, RDPTNP) \quad (1)$$

Where

EC = Economic cost
EAYDP = Expected Annual Yield of Diseased Palms
PUN = Price per Unit Nut
RDPTNP = Ratio of Diseased Palms to Total Number of Palms

In econometric form, the model can be expressed as follows:

$$EC_t= \alpha_o+ \alpha_1 EAYDP_t+\alpha_2 PUN_t+\alpha_3 RDPTNP_t+U_{1t} \quad (2)$$

Where

EAYDP, PUN and RDPTNP are the independent variables already defined for different time period t
α_o is the intercept
α_1, α_2 and α_3 are the structural coefficients to be estimated; and
U_{1t} is stochastic error term
From *a priori* expectation or consideration

$\alpha_{1,}\ \alpha_2$ and $\alpha_{3\ >\ 0,}$

Since increase in any of the explanatory variables (EAYDP, PUN, RDPTNP) would increase economic cost of coconut production as affected by LYD.

Equation (2) is estimated for the four different coconut varieties studied [West African Tall (WAT), Green Dwarf (GD), Malayan Orange Dwarf (MOD) and Malayan Yellow Dwarf (MYD)].

3.6.2 Model 2: Actual Output (AO)

Actual output is hypothesized to be a function of Total Number of Palms (TNP), Number of Diseased Palms (NDP) and Price per Unit Nut (PUN).

In mathematical form the hypothesized relationship may be written as follows:

$$AO= f\ (TNP, NDP, PUN) \quad (3)$$

Where

AO = Actual output
TNP = Total Number of Palms
NDP = Number of Diseased Palms
PUN = Price per Unit Nut

In econometric form, the model can be expressed as follows:

$$AO_t =\beta_0 +\beta_1 TNP_t+ \beta_2 NDP_t + \beta_3 PUN_t + U_{2t} \quad (4)$$

Where

TNP, NDP and PUN are the explanatory variables for different time period t
β_0 = intercept
β_1, β_2 and β_3 = the structural coefficients to be estimated
U_{2t} = error term
From a priori expectation

β_1 and $\beta_{3\ >}0$, $\beta_{2\ <}\ 0$

The actual output of coconut is expected to move in the same direction as total number of palms planted and price per unit nut. This is because higher total number of palms planted by the coconut growers produces more chances of having higher yield. Also, the higher price per unit nut produced corresponds to increased motivation of coconut growers to cultivate more palms and increase the actual output. On the other hand, higher numbers of diseased palms correspond to lower actual output of coconut.

3.6.3 Model 3: Logarithm of Economic Cost (LNEC) – non-linear cost function

Using the logarithms of all the variables in equation (2), we obtain the econometric equation to be estimated as follows:

$$Ln\ EC_t= \alpha_o + \alpha_1 lnEAYDP_t + \alpha_2 lnPUN_t + \alpha_3 lnRDPTNP_t + U_{1t} \quad (5)$$

Equation (5) is a “log linear” or “double log” specification where ln represents the natural log. Note that using a double log specification enables to directly obtain the elasticity of the dependent variable (EC) with respect to each of the explanatory variables in the model. Therefore, $\alpha_{1,}\ \alpha_{2,}$ and α_3 are constant elasticities which tell the degree of responsiveness of economic cost to changes in the explanatory variables. Hence, α_1 gives the elasticity of EAYDP with respect to EC, α_2 gives the elasticity of PUN with respect to EC and α_3 gives the elasticity of RDPTNP with respect to EC. The ordinary least squares (OLS) regression method can be used to estimate the model. Recall that the Gauss-Markov theorem demonstrates that, provided certain fairly general assumptions hold, using the OLS regression technique to estimate the parameters of a single-equation yields coefficient estimates that are best linear unbiased (BLUE) and hence they possess the desirable properties of unbiasedness, consistency and efficiency [22].

3.6.4 Model 4: Logarithm of Actual Output (LNAO) – non-linear function of output

Using the logarithms of the variables in equation (4), the econometric equation is estimated as:

$$\text{Ln } AO_t=\beta_0+\beta_1 \ln TNP_t + \beta_2 \ln NDP_t+ \beta_3 \ln PUN_t + U_{2t} \quad (6)$$

The coefficients β_1, β_2 and β_3 are the elasticities of actual output (AO) of coconut with respect to total number of palms (TNP), number of diseased palms (NDP) and price per unit nut (PUN) respectively.

Equations (2), (3), (5) and (6) are estimated using the collected data and the OLS regression technique.

In summary, the following models are estimated:

Model 1

EC = f (EAYDP, PUN, RDPTNP)

Model 2

AO = f (TNP, NDP, PUN)

Model 3

$$\text{Ln } EC_t= \alpha_o + \alpha_1 \ln EAYDP_t + \alpha_2 \ln PUN_t + \alpha_3 \ln RDPTNP_t + U_{1t}$$

Model 4

$$\text{Ln}AO_t = \beta_0 + \beta_1 \ln TNP_t + \beta_2 \ln NDP_t+ \beta_3 \ln PUN_t + U_{2t}$$

4. RESULTS AND DISCUSSION

Table 1 presents the descriptive statistics of variables used in this study.

The descriptive statistics shows the description of the mean, standard deviation and normality test. The mean of TNP is 444.75, NDP has an average value of 258.35, EC over the period is 3177840, PUN has average value of 64, the mean value of EAYDP is 41336, AO has an average of 29824 and RDPTNP has an average value of 8.98. The standard deviation shows that there was dispersion in the variables over the period of study. This means that no single variable was constant over the period of analysis. The Jarque-Bera statistics shows that the variables were normally distributed at 5% except for TNP, NDP and EAYDP over the period analysed.

With an R^2 value of 0.962210, it is clear that over 96% of the systematic variations in the dependent variable, Economic Cost (EC) is explained by the three independent variables, Expected Annual Yield of Diseased Palms (EAYDP), Price per Unit Nut (PUN), and Ratio of Diseased Palms to Total Number of Palms (RDPTNP).

Overall significance of the model is impressive with F – statistic value of 135.7956 significant at the 10% level. This implies that a linear relationship exists between the dependent and independent variables taken together. Thus, the hypothesis of a linear relationship between economic cost and the repressors cannot be rejected. The Durbin – Watson statistic value of 1.92802 suggests the absence of autocorrelation. Furthermore, the estimated coefficients of EAYDP and PUN are correctly signed and are significant at 10% and 5% respectively. However, RDPTNP coefficient is incorrectly signed and is insignificant (not significantly different from zero).

On the average, a unit rise in EAYDP and PUN would increase EC by approximately 86.51 and 39103.04 units respectively. This shows that EAYDP and PUN are significant determinants of economic cost of coconut production affected by LYD. By implication, the amount of yield that would have been obtained if there was no incidence of LYD would be lost at the rate of 86.51. Also, the economic cost arising from increasing unit price of coconut is at the rate of 39103.04. This is because the lost in yield due to LYD would have attracted such increase in price.

Given the value of R^2, it can be deduced that 100% of the systematic variations in the regressand (AO) are explained by the regressors (TNP, NDP, PUN). This indicates that the regression line perfectly fits the data. The F – statistic value of 5.42E + 30 is highly significant at 10% level, easily passing the significance test at the 10% confidence level. Consequently, the hypothesis of a linear relationship between the regressand and the regressors cannot be rejected (it is validated). Thus, the estimated model shows a reliable goodness -of - fit. The Durbin - Watson's value of 1.96 suggests the absence of autocorrelation in the estimated model. The estimated coefficients meet *a priori* expectations and are highly significant at 10% level except for PUN. It shows that on the average, a unit rise in TNP and NDP will increase and decrease AO by 160 and 160 units respectively. We, therefore, conclude that TNP and NDP are significant determinants of AO of coconuts in the area.

Table 1. Descriptive statistics of variables

STATS	TNP	NDP	EO	AO	EAYDP	PUN	EC	RDPTNP
Mean	444.7500	258.3500	71160.00	29824.00	41336.00	64.00000	3177840.	50.95536
Median	394.5000	99.50000	63120.00	11200.00	15920.00	60.00000	1038400.	48.20072
Maximum	895.0000	849.0000	143200.0	131680.0	135840.0	100.0000	13584000	97.92899
Minimum	95.00000	0.000000	15200.00	1920.000	0.000000	30.00000	0.000000	0.000000
Std. dev.	358.5735	293.4648	57371.76	38228.54	46954.37	24.79389	4228937.	33.95921
Skewness	0.142591	0.927782	0.142591	1.467583	0.927782	0.122440	1.333308	0.094478
Kurtosis	1.190262	2.363809	1.190262	3.870198	2.363809	1.829705	3.365969	1.627379
Jarque-Bera	2.797066	3.206550	2.797066	7.810371	3.206550	1.191297	6.037315	1.599829
Probability	0.246959	0.201236	0.246959	0.020137	0.201236	0.551205	0.048867	0.449367
Sum	8895.000	5167.000	1423200.	596480.0	826720.0	1280.000	63556800	1019.107
Sum Sq. dev.	2442924.	1636311.	6.25E+10	2.78E+10	4.19E+10	11680.00	3.40E+14	21911.33
Observations	**20**	**20**	**20**	**20**	**20**	**20**	**20**	**20**

Source: Authors' computation using Eviews 7

Table 2. Model 1 - Economic Cost (EC) analysis

Variable	Coefficient	t-statistic
C	-2029361	-3.217411
EAYDP	86.50755	12.84347
PUN	39103.04	2.415098
RDPTNP	-17098.68	-1.138677
R^2	0.962210	
$\bar{R}^2$	0.955125	
f-statistic	135.7986	
Durbin Watson statistic	1.928020	

Table 3. Model 2 - Actual Output (AO) analysis

Variable	Coefficient	t-statistic
C	6.51E-11	1.656360
TNP	160.0000	3.15E+15
NDP	-160.0000	-2.26E+15
PUN	-6.75E-13	-1.213842
R^2	1.000000	
$\bar{R}^2$	1.000000	
f-statistic	5.42E+30	
Durbin Watson statistic	1.960328	

Table 4. Model 3 - Logarithm of Economic Cost (LNEC) analysis

Variable	Coefficient	t-statistic
C	-0.971360	-0.470167
LNEAYDP	1.216246	11.46380
LNPUN	0.551719	0.904972
LNRDPTNP	0.169682	0.462761

Table 5. Model 4 - Logarithm of Actual Output (LNAO) analysis

Variable	Coefficient	t-statistic
C	16.91687	3.606117
LNTNP	0.386767	0.798953
LNNDP	0.134842	0.396362
PUN	-2.499259	-2.769229

The estimated results of LNEC model further substantiate that of the EC model. It shows that the elasticity of EC to EAYDP equals 1.21. This means that EC is elastic relative to EAYDP. Furthermore, PUN elasticity of EC is 0.55 indicating that EC is inelastic relative to PUN.

The LNAO model reveals that the coefficients of the explanatory variables are not significant except for PUN; which is significant at 5% level. Its value of – 2.499259 shows the PUN elasticity of AO. In absolute terms, this value is greater than unity, indicating that AO is elastic with respect to PUN.

5. CONCLUSION

The research demonstrates the economic cost of lethal yellowing disease on coconut yield in Nigerian Institute for Oil Palm Research. Estimated regression results of the period 2000 to 2010 show that expected annual yield of diseased palms and price per unit nut have positive significant impact on economic cost of coconut. Also, while total number of palms has a significant impact on actual output, number of diseased palms has significant negative impact on actual output. It is evident from the study that LYD has a devastating effect on coconut yield.

Having demonstrated the economic cost of LYD on coconut yield, it is recommended that preventive and control measures such as planting of cover-crops that do not harbour the vector, uprooting infected palms, planting of tolerant coconut varieties, antibiotic treatment using oxtetracycline-hydrochloride injection and the use of insecticides should be carried out to reduce the incidence of the disease.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Table of coconut production, 2000 – 2010

Year	Coconut varieties	Total number of palms	Number of diseased palms
2000	WAT	676	98
2000	GD	95	0
2000	MOD	113	6
2000	MYD	895	72
2002	WAT	676	303
2002	GD	95	16
2002	MOD	113	39
2002	MYD	895	293
2004	WAT	676	480
2004	GD	95	29
2004	MOD	113	68
2004	MYD	895	474
2006	WAT	676	658
2006	GD	95	32
2006	MOD	113	101
2006	MYD	895	837
2010	WAT	676	662
2010	GD	95	49
2010	MOD	113	101
2010	MYD	895	849

Source: Plant Breeding Division, Nigerian Institute for Oil Palm Research (NIFOR), Benin City, Edo State, Nigeria

Regression data

OBS	TNP	NDP	EO	AO	EAYDP	PUN	EC	RDPTNP
1	676	98	108,160	92,480	15,680	30	470,400	14.50
2	95	0	15,200	15,200	0	30	0	0.00
3	113	6	18,080	17,120	960	30	28,800	5.31
4	895	72	143,200	131,680	11,520	30	345,600	8.04
5	676	303	108,160	59,680	48,480	50	2,424,000	44.82
6	95	16	15,200	12,640	2,560	50	128,000	16.84
7	113	39	18,080	11,840	6,240	50	312,000	34.51
8	895	293	143,200	96,320	46,880	50	2,344,000	32.74
9	676	480	108,160	31,360	76,800	60	4,608,000	71.01
10	95	29	15,200	10,560	4,640	60	278,400	30.53
11	113	68	18,080	7,200	10,880	60	652,800	60.18
12	895	474	143,200	67,360	75,840	60	4,550,400	52.96
13	676	658	108,160	2,880	105,280	80	8,422,400	97.34
14	95	32	15,200	10,080	5,120	80	409,600	33.68
15	113	101	18,080	1,920	16,160	80	1,292,800	89.38
16	895	837	143,200	9,280	133,920	80	10,713,600	93.52
17	676	662	108,160	2,240	105,920	100	10,592,000	97.93
18	95	49	15,200	7,360	7,840	100	784,000	51.58
19	113	101	18,080	1,920	16,160	100	1,616,000	89.38
20	895	849	143,200	7,360	135,840	100	13,584,000	94.86

Source: Authors' calculations 2015

Note: PUN = price per unit nut is in naira (₦)

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