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Costing and Statistical Investigation of Steel Bars Produced from Scrap in Lagos State, Nigeria

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Abstract This paper reveals field survey of ten year price distribution and the degree of uncertainty or dispersion in the size geometry of local and imported bars. The study separates cost price and strength the main parameters needed when selecting ideal steel rebars, which is very fundamental to the development of reliable standard of practice for building and civil engineering industry. Lagos highland especially Ogba reinforcement bars sample has the highest mean, standard deviation and coefficient of variation (COV) of Y25 (24.8), Y16 (σ0.095) and (0.81%) respectively. Likewise, the study of the price from various Lagos zone (island and highland) would enable the engineers, project managers or clients construction professionals to assess whether the price different or matches the strength difference. Finally, the research investigation is a basis for the development of acceptable standards or codes of practices for design that takes into account the geometry and strength of materials for construction of RC building and civil infrastructure in Nigeria.

Keywords Dispersion Degree, Costing, Lagos, Steel Rebars

1. Introduction

Reinforced concrete, as the most widely used construction material, plays a vital role in global economic growth and infrastructural development (Rojacz et al. 2013; Yeon et al 2007; Basu et al 2004). Reinforced concrete is a composite material made up of concrete plus reinforcing bars (rebar). Concrete as a brittle material, has slight tensile strength, which is an adverse trait for a construction material (Ede 2010; Hashemi 2006; Logan 2000).

In actual fact, reinforced concrete constitutes over ninety percent (90%) of infrastructure systems in unindustrialized or developing republics, even with the advances in emerging technologies as well as innovative materials, not less than seventy- five percent (75%) is being utilized for constructed amenities in the industrialized countries (Balogh and Vigh 2013; Ede 2010; kosmatka et al. 2003). The networks of civil infrastructure as well as constructed facilities for example bridges, roads, buildings, tunnels, dams and retaining wall, telecommunications installations, transportation systems, water resources, nuclear power plants, and wastewater systems and other life-supporting facilities aid in delivering essential services, shelter provider, structural foundations, support social teamwork and economic improvement (Harara et al. 2013; Vigh 2013). For all intents and purposes, the sustainable economic growth, throughput or productivity, and the good fortune of a nation is being determined heavily based on its functionality, consistency or reliability, as well as durability of its civil infrastructure structures (Balogh and Vigh 2013; Yeon et al. 2007).

Rebar is introduced to concrete to increase its ductility and to regulate widths of crack (Harara et al. 2013). Whether the rebar is made of fiber reinforced polymers or steel, tensile stresses must be transmitted from the concrete to the rebar. The transfer of stress from the concrete to the rebar is achieved through bond amongst the two materials (Balogh and Vigh 2013; MIT 1999). In order to achieve an acceptable probability or likelihood that any designed structure might perform satisfactorily all through their intended life, steel rebar must compliance with design code specification before used during construction deeds (Maghsoudi and Akbarzadeh 2006; Basu et al. 2004; Oyenuga 2000). BS 1881-124: 2015 and BS 8110:1-2002 testified that concrete materials is often hampered by non-conformity with structural design stipulations and non-conformance of structural properties of materials utilized in the actual construction compared, to the properties of materials specified at the designed stage. In recent times, structural catastrophe of both building and civil infrastructure is on the rise in Nigeria. Even if structure has sound analysis and design it can still fail, if the quality of the material utilized for the construction is bad. Statistics have exposed that a significant number of structural catastrophes could be credited to influx of impostors and/or wrong professional practices, bad material quality, poor construction approach, workmanship and unsubstantiated newly introduced reinforcement (Erhard 2006; Chahrour and Soudki 2005; Castro et al. 2002; Clifton and Marthey 1983).

The two major materials utilized for constructional reasons in reinforced concrete structures are reinforcement bars and concrete. Attaining an acceptable possibility that any designed structure can perform satisfactorily during their envisioned life is frequently hampered thru non-compliance of structural design specifications as well as non-conformance of structural properties of materials used in the real construction to the properties of materials indicated at the designed stage (Balogh and Vigh 2013; Bellis 2011; Clifton et al. 1999; MIT 1999). In contemporary times, structural failure of civil as well as building infrastructure is upsurge in Nigeria (NIS 1992). Despite the fact that so many investigations and probes have been performed on the worrisome trends of structural collapse in Nigeria from social sciences, environmental as well as engineering points of view (Ede, 2010; Oyenuga 2000; Phillips 1998), this study attempts to address the impact of dispersion coefficient, and also related issues, as well as the effects of prices on various aspects of characterization of locally produced steel reinforcing bars (rebars)

1.1. Historical Overview of Steel Production in Nigeria

Rebars are rolled from billets that are found from a furnace (Rojacz et al. 2013; Yeon et al. 2007). Billets can be formed either from iron-ore through the blast furnace converter channel, or by melting scraps as well as refining the same in the furnace (Erhard 2006; Gilchrist and Thomas 1879). The prominent steel companies in Nigeria are the Delta Steel Company Limited, Aladja, Warri as well as the Ajaokuta Steel Company Limited, Ajaokuta. These two corporations manufactured steel from unprocessed or raw materials either as finished products or steel billet which are semi-finished products. The companies supplied billets to the three inland rolling mills, which are Oshogbo Steel rolling company, Oshogbo, Katsina Steel rolling company, Katsina and the Jos steel rolling company Jos (Ede 2010; Oyenuga 2000). These rolling companies manufactured the finished steel products from billets. The Delta steel corporation, Aladja has yearly rolling capacity of three hundred and two thousand (320, 000) tonnes whereas the Ajaokuta Steel Company Limited had a design capacity of one point three millions (1.3 millions) tonnes. Every one of the three steel rolling companies, Oshogbo, Jos and Katsina had a rolling capacity of two hundred and ten thousand (210,000) tonnes. These companies, nonetheless, are categorized by low capacity utilization attributable to lack of adequate sourcing of raw materials or semi-finished products, as well as effective funding for maintenance and technical operations (Kayali and Zho 2005; Phillips 1998).

Locally manufactured or factory-made reinforcing steel bars from scrap metal are becoming very common in Nigeria in particular and Africa at large. In developing republics such as Nigeria where imported steel manufactured to world best standards is at high-priced, milling companies as well as private individuals have taken up the challenge or conundrum to re-cycle obsolete vehicle, machine metal parts and household metal rubbish or waste for the production of structural and reinforcing steel. The typical of the registered indigenous steel rebar manufacturing industries that use scraps as their major raw materials for producing steel include Nigerian Spanish Engineering Ltd, Kano, African Steel Nig. Ltd, Ikorodu, Lagos, Continental Iron and Steel Company (CISCO) Ikeja, Lagos, Unique Steel Industres, Ltd, Lekki, Lagos, Universal Steel Company Ikeja, Lagos, Sun Flag Nigeria Ltd, Ikorodu, Lagos, among several others. In actual fact, preliminary investigations publicized that there are scores of such local steel companies operating in Nigeria, legally and illegitimately (Ede, 2010); Oyenuga 2000; Phillips 1998).

To cut a long story short, the steel reinforcing bar required for structural concrete is partially or partway produced by the country's inland rolling mills while the balance is sourced through import. The importation is carried out mostly thru private entrepreneurs and the attribute of such imported product is always neither guaranteed nor sure fire, as they are essentially brought in from diverse sources without any comprehensive as well as methodical standardization process regarding their structural properties (Kankam and Adom-Asamoah, 2002; Kankam and Odum-Ewuakye 2001; Logan 2000; Neville and Brooks 1994). Consequently, differences are bound to arise in the strengths, and feasibly, geometry of steel assumed in design as well as those used for actual construction, unless tests are carried out on every batch of imported steel delivered on construction site. With the near collapse of the government-owned rolling mills and dwindling performance of the privatized counterparts in an unfriendly economy, influx of steel rebars from questionable sources are the order of the day in Nigerian markets.

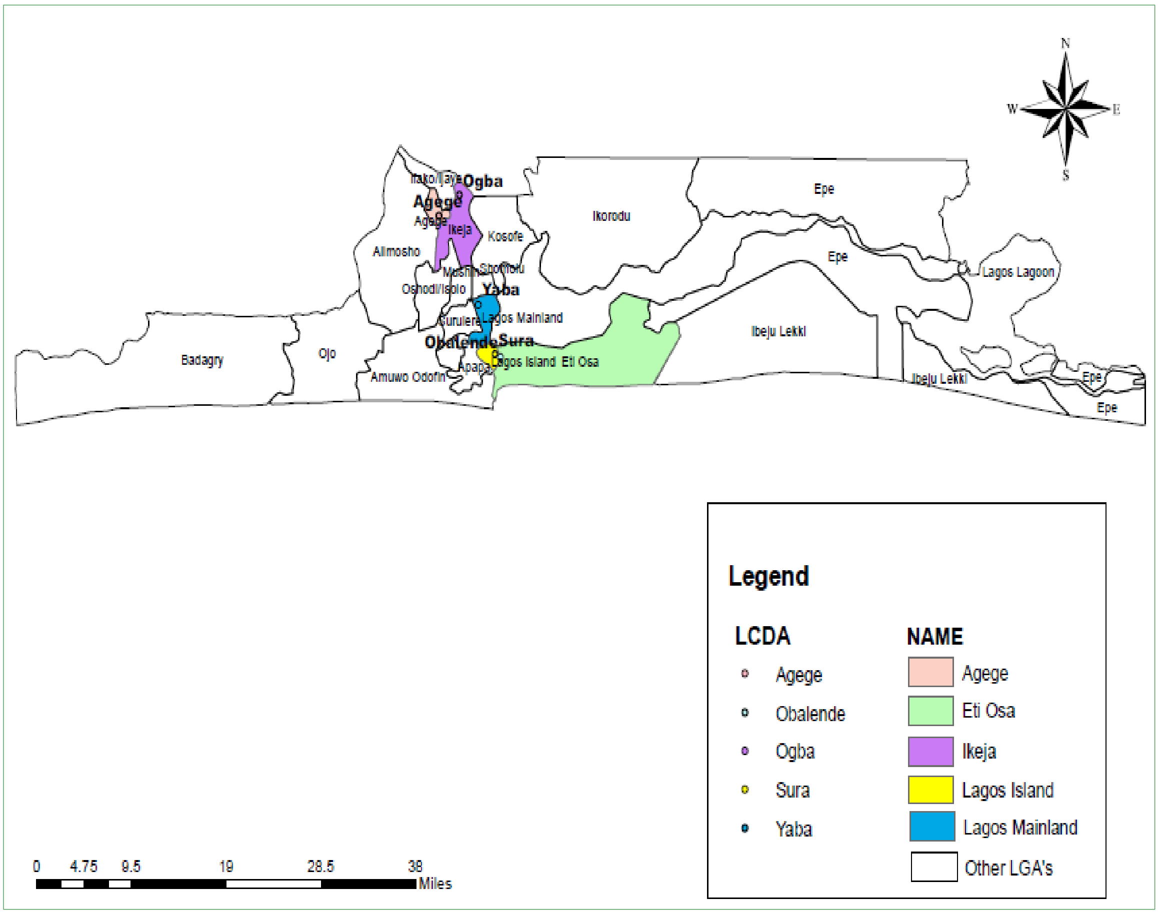


Figure 1. Lagos state map showing the study localities for both island and highland

2. Methodology

2.1. Study Zone Description

Lagos is a state in the southwestern geopolitical region as well as the largest Nigeria state with GDP of US$33,679 million, the nation-state's largest urban district, major financial center, one among fastest developing metropolises in the world and fourth (4^{th}) highest GDP as well as largest economy in Africa. This megacity houses largest and busiest seaports at Apapa, Lagos Island and international airport at Ikeja, Lagos highland. It is bordered on the north as well as to the east by Ogun state, while in the west the Republic of Benin. In the rear, its southern boarders lies the Atlantic Ocean with twenty-two percent (22%), out of its 3,577 Km^2 are lagoons as well as creeks with coordinates of 6^0 35N and 3^0 45E, which also graphically demonstrated in Figure 1.

2.2. Materials and Methods

Field survey which includes market survey/pricing and statistical evaluation of size distributions of locally made steel rebars. Size distribution of the steel rebars was carried out through market survey of two different zones namely Lagos island and highland. A total of fifty (50) steel rebar major distributors was visited in each of the two zones so as to determine the real sizes of different steel rebar types available. Ten year market price survey was conducted per tonnage of 10 mm – 25mm diameter steel rebar for local types.

3. Result and Discussion

3.1. Statistical Analysis of the Lagos Steel Bars Distribution

Mean Value

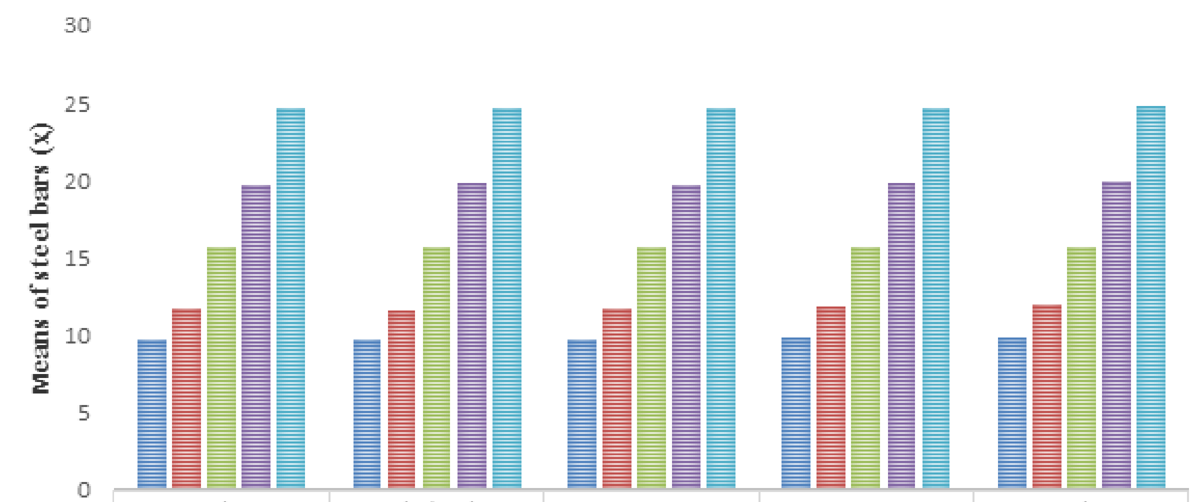
The mean values of steel rebars recorded from five localities are presented in Figure 2.

Standard Deviation

The standard deviation values of steel rebars recorded from five localities are presented in Figure 3.

Coefficient of Variation (COV)

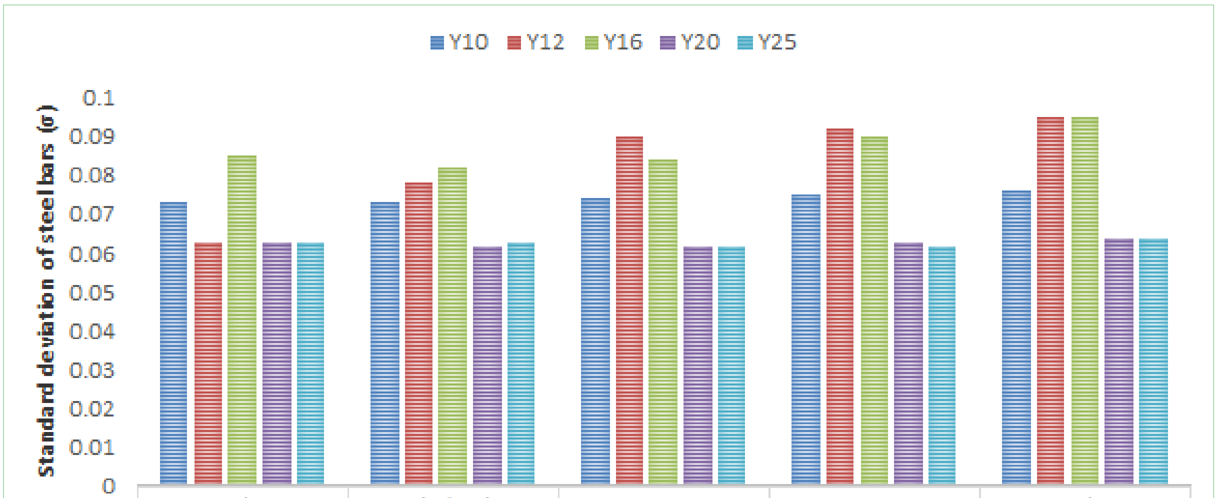
The coefficient of variation value of steel rebars recorded from five localities is presented in Figure 4.



	Yaba	Obalende	Sura	Agege	Ogba
Y10	9.76	9.76	9.75	9.77	9.78
Y12	11.7	11.6	11.7	11.8	11.9
Y16	15.7	15.72	15.71	15.73	15.74
Y20	19.7	19.8	19.7	19.8	19.9
Y25	24.6	24.6	24.6	24.7	24.8

Steel locations

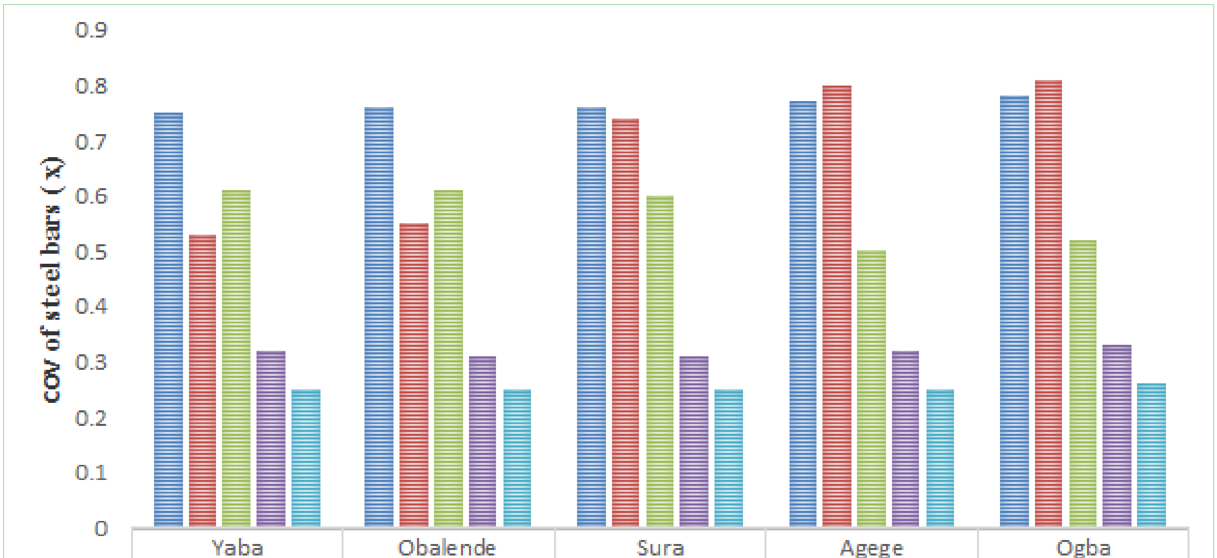
Figure 2. Means of steel bars from various locations



	Yaba	Obalende	Sura	Agege	Ogba
Y10	0.073	0.073	0.074	0.075	0.076
Y12	0.063	0.078	0.09	0.092	0.095
Y16	0.085	0.082	0.084	0.09	0.095
Y20	0.063	0.062	0.062	0.063	0.064
Y25	0.063	0.063	0.062	0.062	0.064

Steel locations

Figure 3. Standard deviation of steel bars from various locations



	Yaba	Obalende	Sura	Agege	Ogba
Y10	0.75	0.76	0.76	0.77	0.78
Y12	0.53	0.55	0.74	0.8	0.81
Y16	0.61	0.61	0.6	0.5	0.52
Y20	0.32	0.31	0.31	0.32	0.33
Y25	0.25	0.25	0.25	0.25	0.26

Figure 4. Coefficient of variation (COV) of steel bars from various locations

Figure 2 - 4 reveals that Ogba reinforcement bars sample has the highest mean, standard deviation and coefficient of variation (COV) of Y25 (24.8), Y16 (σ0.095) and (0.81%) respectively.

All the parameters were consider for the steel rebars of range 10 mm to 25 mm are the mean ($\bar{x}$), standard deviation (σ), variance (σ^2) and the coefficient of variation (COV). The coefficient of variation give the most reasonable consideration, it shows the percentage of standard deviation to the mean.

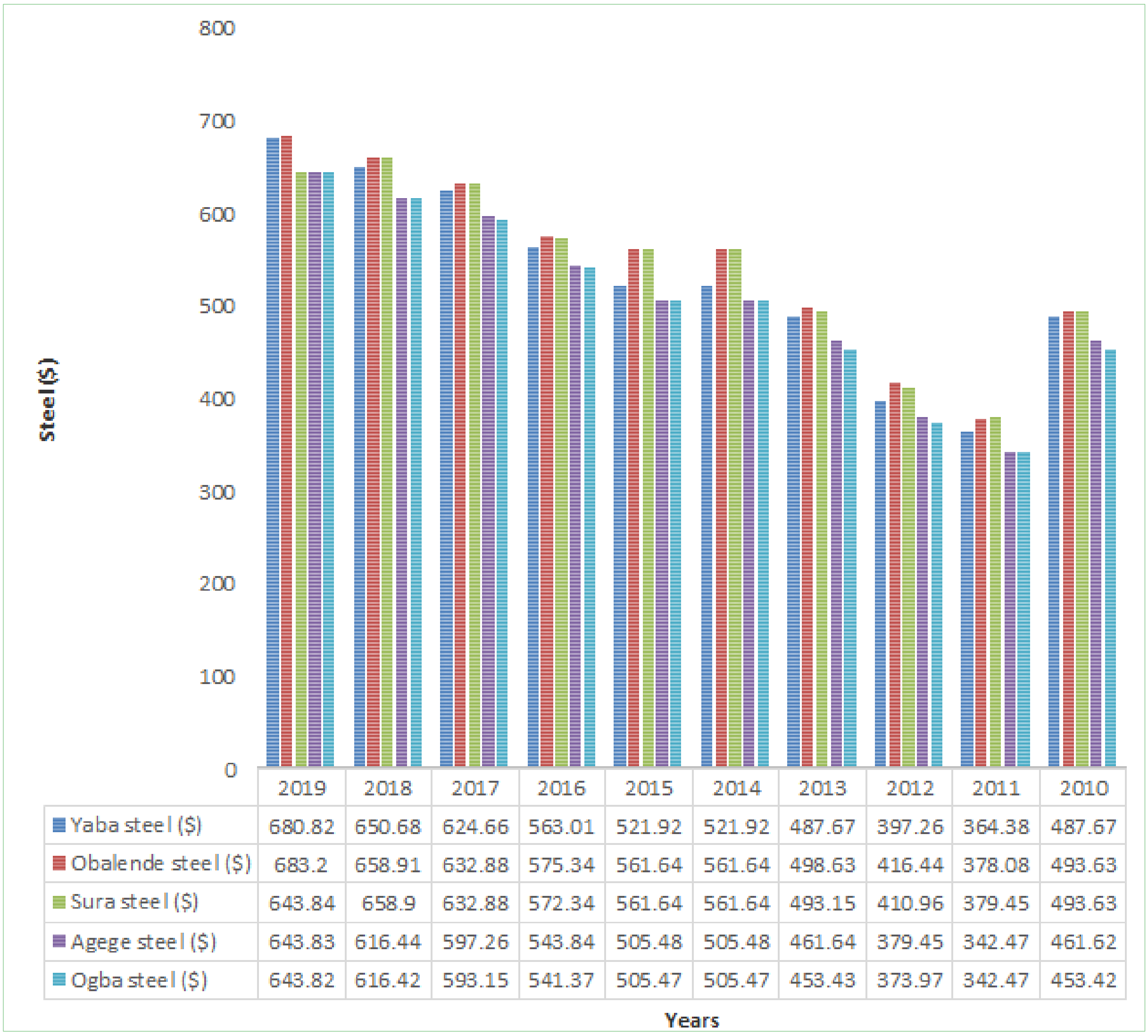
It is obvious that in Lagos metropolis, the mean bar sizes for the different diameter of rebars considered for the Lagos highland are higher in diameter that the corresponding Lagos island type, with a very small margin. That is, Highland reinforcing bars, mean value is within 9.77 to 24.8 and the Lagos Island reinforcing bars in the range of 9.75 to 24.6 for the same diameter size range. Meanwhile, for Highland reinforcing bars, standard deviation value is in the range of 0.064 to 0.075 and the Lagos Island reinforcing bars in the range of 0.063 to 0.073 for the same diameter size range. Also, there is a smaller degree of uncertainty in the Lagos Highland reinforcing bars size having COV in the range of 0.26 to 0.77 and the Lagos Island reinforcing bars in the range of 0.75 to 0.25 for the same diameter size range. Therefore, from the analysis, imported bars in relation to the sizes specified by British standard can still be considered for structural purposes, though not without proper assessment of the tensile strength properties. The statistical analysis of steel size distribution can be compared to that of Lagos highland because of the big market for steel in Lagos highland which is source of supply to Lagos island metropolis.

From the two study areas, the degree of uncertainty in Lagos Island is small compared to that of Lagos highland. However, if we have to consider the sizes of steel made with imported billet and thermo mechanically treated (TMT product), as testified by Ede (2010) and Phillip (1998), the degree of uncertainty is almost the same. This is probably due to recent monitoring by Standards Organization of Nigeria (SON) to ensure quality and standardized steel in the country.

3.2. Cost Analysis

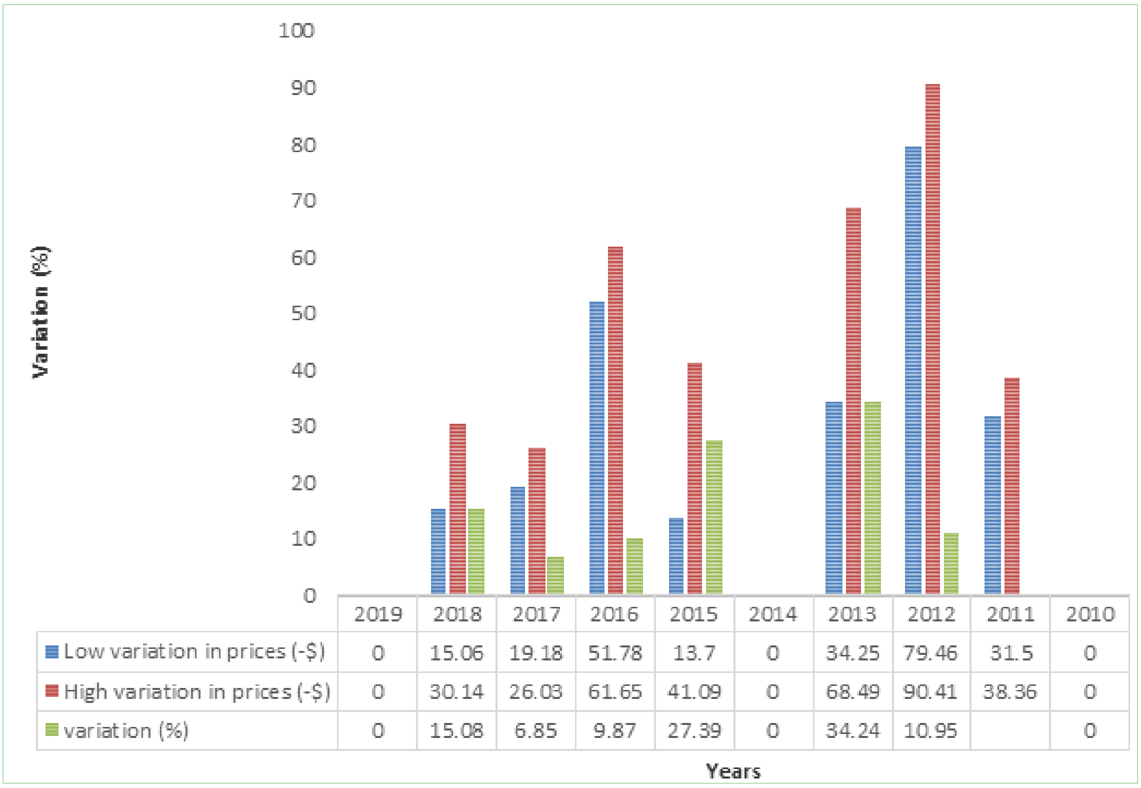
The reinforcement costing values through random survey for ten (10) years are displayed in Figure 5. While, the variation between lower and high prices for reinforcement bars at five localities for ten (10) years are displayed in Figure 6.

Figure 5 indicates the trend for the costing of locally made, semi-locally made and foreign reinforcement from 2010 to 2019, While Figure 6 shows high fluctuations especially from year 2010 to 2019.



	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Yaba steel ($)	680.82	650.68	624.66	563.01	521.92	521.92	487.67	397.26	364.38	487.67
Obalende steel ($)	683.2	658.91	632.88	575.34	561.64	561.64	498.63	416.44	378.08	493.63
Sura steel ($)	643.84	658.9	632.88	572.34	561.64	561.64	493.15	410.96	379.45	493.63
Agege steel ($)	643.83	616.44	597.26	543.84	505.48	505.48	461.64	379.45	342.47	461.62
Ogba steel ($)	643.82	616.42	593.15	541.37	505.47	505.47	453.43	373.97	342.47	453.42

Figure 5. Costing of reinforcement from 2010 to 2019



	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
Low variation in prices (-$)	0	15.06	19.18	51.78	13.7	0	34.25	79.46	31.5	0
High variation in prices (-$)	0	30.14	26.03	61.65	41.09	0	68.49	90.41	38.36	0
variation (%)	0	15.08	6.85	9.87	27.39	0	34.24	10.95		0

Figure 6. Variation between low and high prices

Lagos metropolis was taken as point of reference because of the huge steel industries location in this part of the country. It was perceived that there were wide variation in prices of steel brand based on vicinities and urbanization. It was also publicized that cost of reinforcement in Lagos Island is higher than Lagos highland; this may also be reason for constant building collapse at Lagos Island. The owners and contractor care less about strength requirement, because as developer making money from overcrowded population is their goal. The price survey is based on imported and local steel rebar for period of ten years. The value of imported and local steel rebar was at its apex value of $ 493.63 in 2010, whereas in 2011 was $ 379.45, But in 2012 the steel rebar was its peak value of $ 416.44. From 2013 to --- it increasing rapidly with values of $ 498.63; $ 561.64; $ 561.64; $ 575.34; $ 632.88; $ 658.91 and $ 680.82). The price of local and imported steel bars rising swiftly can be attributed to change in government and other factors like construction policies, increase in demand or when the regulatory bodies such as SON took the standard strength of steel into consideration, and increased nationwide awareness of the strength of steel in structural stability of concrete structure in the face of incessant collapse of built and on-going building and civil structures.

4. Conclusions

This paper showed that Lagos highland especially Ogba reinforcement bars sample has the highest mean, standard deviation and coefficient of variation (COV) of Y25 (24.8), Y16 (σ0.095) and (0.81%) respectively. Also, the market price survey of Lagos reinforcement bars showed that Lagos highland areas were cheaper than Lagos Island (Yaba, Obalende and Sura). The price survey is based on imported and local steel rebar for period of ten years. The value of imported and local steel rebar was at its apex value of $ 493.63 in 2010, whereas in 2011 was $ 379.45, But in 2012 the steel rebar was its peak value of $ 416.44. From 2013 to --- it increasing rapidly with values of $ 498.63; $ 561.64; $ 561.64; $ 575.34; $ 632.88; $ 658.91 and $ 680.82). All locally made bar price trend was characterized by higher fluctuations. Though, engineer as well as builder patronize it, but compromised strength requirements especially in the island. Conclusively, the price of reinforcing steel bars growing expeditiously can be as a result of change in government and other factors such as construction policies, increase in demand or when the regulatory bodies like SON took the standard strength of steel into consideration, as well as increased coast-to-coast or nationwide awareness of the strength of steel in structural stability of concrete structure in the face of never-ending collapse of built and on-going building and civil structures.

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