Regression Modelling of Electricity Distribution Statistics and Stock Exchange Market Capitalisation in a Developing Country: Evidence from Botswana (2012-2021)

Tapiwa Gande [ORCID]

School of Post Graduate Studies (SPGS), Botswana Accountancy College, Gaborone, Botswana
Email: tapiwag@bac.ac.bw

Abstract

The stock exchange and its performance are important indicators of the economic health of an economy. Electricity generation capacity supports industrialisation. National electricity distribution on the other hand, however, even when mediated with electricity imports to augment a low generation capacity, can complicate both manufacturing and non-manufacturing companies' desire to operate in an economy which is attempting to industrialise. This is compounded if generation is not matched to consumption patterns, electricity demand and is supported by a robust and efficient network facility that monitors the grid and balances generation, distribution, and demand while minimising leakages through unauthorised connections. The research aims to ascertain the relationship between electricity distribution and stock market performance in a developing country over a ten-year period (2012-2021). Stock market performance is measured using overall stock market capitalisation. The relationship between Botswana's electricity distribution against the country's stock market performance has not been studied and modelled prior. The data used for the regression modelling of electricity distribution was obtained from the official national statistics parastatal, Statistics Botswana. The data in quarters of a year, as mega-watt hours (MWH) per year from 2012 to 2021 was employed in this research. Natural logarithms, which do not inherently minimise the effects of skewness in a dataset, were used to minimise the effects of skewed distributions and heteroscedasticity of the data in this period. Similarly, natural logarithms were applied to quarterly Pula (millions) value total stock market capitalisation from the Botswana Stock Exchange (BSE) annual reports over the same period. The findings indicate that although electricity distribution is negatively correlated to stock market performance as measured

by total market capitalisation, electricity generation can predict stock market performance to within a less than 6% variance level between predicted and actual quarterly measures of total stock market capitalisation. In the context of Botswana, a country classified as upper-middle income, but is still dependent on diamond mining, the limited job creation in the economy could be addressed by investigating the link between electricity distribution and stock market capitalisation in the wider efforts to industrialise and diversify the economy by attracting listed companies. The implication of the regression model developed from the findings and prediction of stock market performance through total market capitalisation is that, the power utility and government should manage electricity distribution with care and foresight so as to positively impact stock market performance as electricity distribution is a good macro-indicator of economic health and could be a crucial factor that multinationals (MNCs) looking to invest in Botswana would consider.

Subject Areas

Business Analysis, Business Research Methods, Development Economics, Economic System, Electric Engineering, Engineering Management, Finance

Keywords

Stock Market Capitalisation, Electricity Distribution, Regression

1. Introduction

The relationship between stock market capitalisation and electricity distribution is of immense importance and interest to finance and accounting professionals when it is juxtaposed against the energy distribution into an economy that is pivoting itself towards industrialisation and aiming to reduce dependence on mining and tourism. Botswana's dependence on mining and tourism is as well documented as it is problematic [1] [2] [3]. Total market capitalisation is an important indicator of progress towards industrialisation, if share issues, share splits, delistings from the stock exchange, mergers, and acquisitions, share ownership concentration and initial public offerings (IPOs) are not considered. The justification to remove stock market factors such as new share issues, suspensions, share splits, new listings through initial public offerings (IPO), delistings from the stock exchange, mergers and acquisitions and other factors that affect stock market capitalisation from the regression model are that, a multiple regression would have required consideration of these variables and the use of advanced means of factoring outliers such as the mean absolute deviation, trimmed means or boxplots [4] [5].

On the other hand, electricity generation and its attendant challenges, least of which is the global trend towards renewable and sustainable energy sources [3] are assumed to be a given and a long-term aspiration for a third world country such as Botswana. These are part of the strategy support to Botswana by conti-

nental financiers such as the African Development Bank (ADB) to increase electricity generation in the country over the next 20 years with initiatives such as 1) Biogas Pilot Project; 2) Rooftop Solar Photovoltaic Program; 3) Off Grid Solar Program among others, whereby, on a least cost basis, solar photovoltaic (solar PV) was found to be on the low cost of a spectrum with light fuel oil (LFO) on the highest cost end of the spectrum [6].

Currently, Botswana imports substantial electricity from its giant economic neighbour South Africa [7], and the historical relationship between electricity distribution and total market capitalisation can be used to model the status quo and predict short-term patterns of market capitalisation to inform researchers and policymakers on the impact of distribution of energy into the economy. As of year-ended 2021, the Total market Capitalisation of the Botswana Stock exchange as percentage of GDP was 208.5, down from 240.3 in 2017 [8].

1.1. Background

National electricity energy in Botswana is generated from a sole coal-fired power plant with four units with an installed capacity of 33 MW at Morupule Power Station in central Botswana [7]. Botswana's stock market, the Botswana Stock Exchange (BSE), is split between two groupings, Domestic and Foreign, with two separate indices for each. Market capitalisation figures are produced in an annual report by the demutualised bourse for four quarters in the year covering the Domestic and Foreign sections with a total market capitalisation for each quarter. The BSE has been highlighted as one of the best-performing stock markets, averaging 24% return over a 10-year period [9].

The overview of the electricity distribution (in megawatt hours (MWH) in Botswana from 2012 to 2021 by year and quarter together with the Botswana Stock Exchange (BSE) total market capitalisation figures (in millions of Pula) is charted as below.

The dual coordinate chart is a combination of electricity distribution (in MWH) on the right vertical (or y) axis in (Pm) and market capitalisation on the left vertical (second y) axis in millions of Pula. Dual axis charts are useful in presenting different kinds of information on the same chart. In the chart, dual lines representing electricity distribution statistics (in MWH) together with a line representing total market capitalisation are plotted together, with the periods from 2012 to 2021 on the horizontal axis, additionally represented with four quarters in each year. The four quarters in each year are, 1) Q1—January to March; 2) Q2—April to June; 3) Q3—July to August; 4) Q4—September to December.

Chart 1 shows an interesting visual relationship between total stock market capitalisation and electricity distribution, with market capitalisation dipping from the third quarter of 2017 to below P420,000m and not having recovered to its previous highest level of P422,000m in the second and third quarters of 2012. Electricity distribution on the other hand has only just recovered from quarters 2, 3 and 4 of 2014, which achieved highs of above 1 m MHW.

BSE Market Capitalisation (Pm)
&
Electricity Distribution (MWH)
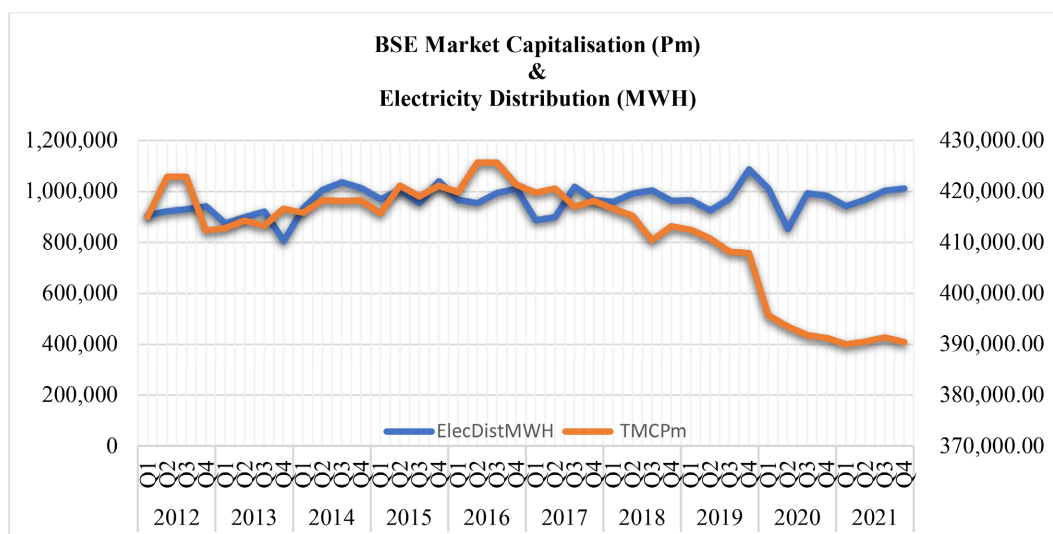
Source: Compiled from [7] and [8]

Chart 1. Overview of Botswana stock market capitalisation (Pm) and electricity distribution (MWH).

1.2. Research Aim

The research aims to explore the linkage or relationship between electricity distribution and stock market capitalization in Botswana. The justification for this is that since the stock exchange market capitalization is a measure of the total value of all listed companies on a stock exchange, it is an important indicator of a country's economic performance and investor confidence. By analysing the relationship between electricity distribution and stock market capitalization, the research seeks to gain insights into how developments in the electricity sector can influence the overall economic growth and investment climate in Botswana.

The research objective is to use the official data from the Botswana Stock Exchange annual reports and electricity generation data from the parastatal organisation charged with the mandate to collect and disseminate all official statistics in Botswana to model a regression formula to predict the relationship of electricity generation on total stock market capitalisation.

1.3. Research Gap

While research from other parts of the world such as Brazil has applied Modern Portfolio Theory (MPT) to electricity systems [11], a global perspective to forecast electricity generation potentials until 2050 shows that projected growth trend of various electricity generation technologies, including biomass, marine, onshore, and offshore wind, solar photovoltaic, concentrating solar power (CSP) technologies, nuclear fission, geothermal and hydropower, will result in production of sufficient energy to meet global demand, even considering fossil fuel [12] which include coal. Coal is a crucial element of Botswana's current electricity generating means.

From this perspective, even though the generating trends globally might indicate a shift towards more renewable energy sources, the generating profile of
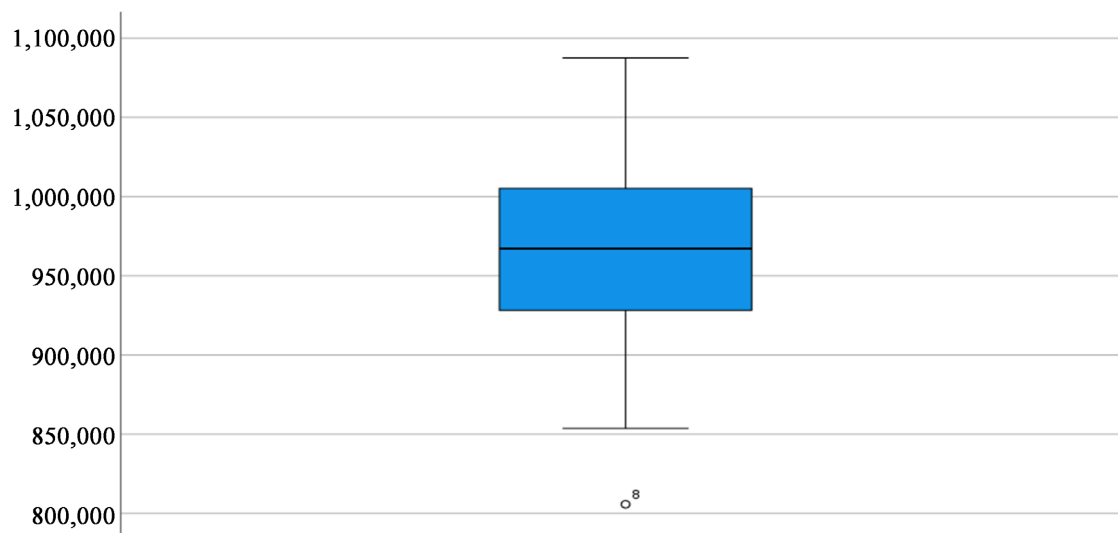
Physical Volume of Electricity Distribution

For the physical volume of electricity distribution (MWH), one mild outlier, data point 8 (being the quarter 4 of 2023 805,758MWH electricity distribution is identified.
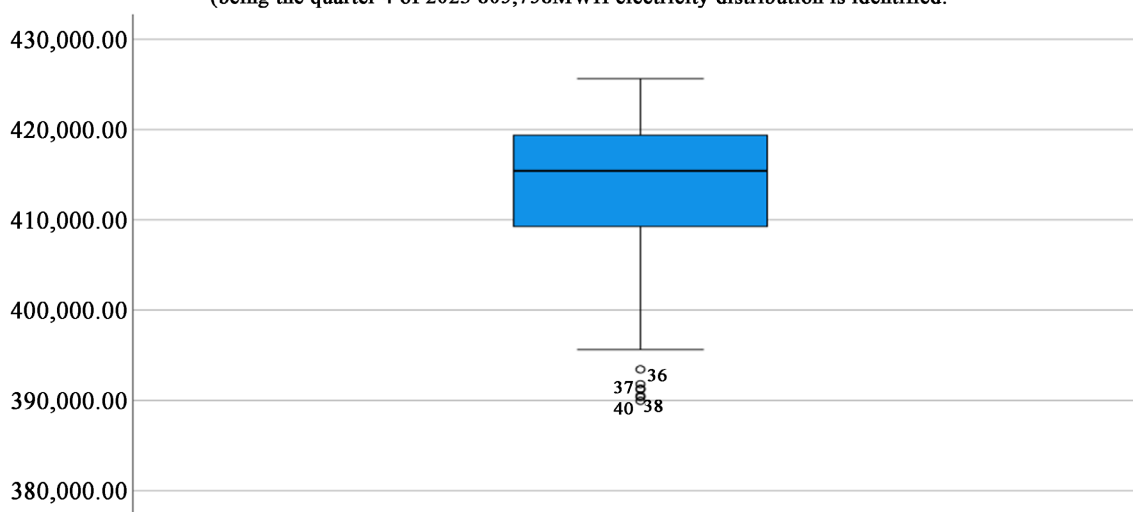
Total Market Capitalisation (Pm)

For total market capitalisation, four mild outliers were found being data points 36, 37, 38 and 40 (being Q4 of 2020, Q1 of 2021, Q2 of 2021 and Q4 of 2021 respectively).

A boxplot visual illustration [10] of whether the distribution of the two datasets for electricity generation and total market capitalisation to ascertain whether either is positively or negatively skewed is shown here. The five number summary of; 1) minimum value that is not an outlier, represented by the bottom of the vertical line (whisker) that extends from the bottom of the box; 2) first quartile (Q1), the value below which 25% of the values in the data set are found; 3) median, the value that separates the higher half of the data set from the lower half; 4) third quartile (Q3), the value below which 75% of the values in the data set are found; 5) maximum value that is not an outlier, represented by the top of the vertical line (whisker) that extends from the top of the box; 6) interquartile range (IQR), the box in the boxplot, being the middle 50% of the data set (between Q1 and Q3), is used [10]. Mild outliers are values that are more than 1.5 × IQR *below* Q1 or *above* Q3 and are represented by circles. No extreme outliers, that is, values that are more than 3.0 × IQR *below* Q1 or *above* Q3 were identified in both the electricity distribution (in MHW) and the total market capitalisation figures (in Pm) (Figure 1).

Figure 1. Box plots of electricity generation and total market capitalisation.

Botswana is assumed to remain dominated by fossil (coal)-based fuel. Research linking finance, through stock market capitalisation and electricity distribution

(albeit with imported electricity dominated by South Africa, which uses some nuclear fuel in generation), is an area of academic research that shows a gap that this paper attempts to address.

A potential research gap can be identified in the limited literature or empirical studies that specifically explore the relationship between electricity distribution statistics and stock exchange market capitalization in the context of a developing country like Botswana. While there may exist studies examining the relationship between electricity distribution and economic indicators or stock market performance in developed nations, there is a scarcity of research that focuses on this relationship in the specific context of a developing country such as Botswana. Botswana, as a developing country, presents a unique set of circumstances and challenges that may influence the relationship between electricity distribution and stock market capitalization and the result of similar studies from developed nations might not be a true representation of what is obtainable in Botswana. Thus, conducting a research study in this light is pertinent.

Hence, addressing this research gap could provide valuable insights into the dynamics and interplay between electricity distribution and stock market performance in a developing country context. It may also shed light on the specific factors and mechanisms that drive or hinder the relationship, offering policymakers and investors a better understanding of the implications and potential strategies to enhance both electricity distribution and stock market development in similar contexts.

1.4. Conceptual Framework

The research does not consider the technical elements of electricity generation. There is an appreciation however that electricity generation might not be able to meet electricity demand. In this instance, there could either be load-shedding to match demand with generation. Load-shedding is undesirable to consumers. Another option could be to augment generation with imports or allow some non-utility players to generate electricity and feed it into the national grid.

Botswana has substantial electricity imported from the Zambia Electricity Supply Corporation Litmited (ZESCO), Electricidade de Mozambique (EDM), Southern African Power Pool (SAPP), Nampower (Namibia) and Eskom (South Africa) [8]. The country's efforts to generate adequate electricity to satisfy local demand has been reported as being on a downward trend when reported in a linear fashion, showing a decreased reliance on electricity imports [8]. This reported trend is not tested as only electricity distribution, mediated by imports has been included in the conceptual framework in Figure 2.

This research framework focuses on the distribution stage and attempts to directly relate this directly to stock market performance. The mediating role of electricity imports is considered as that of augmenting local generation and imported electricity is assumed to beef up local generation and augment total electricity distribution.
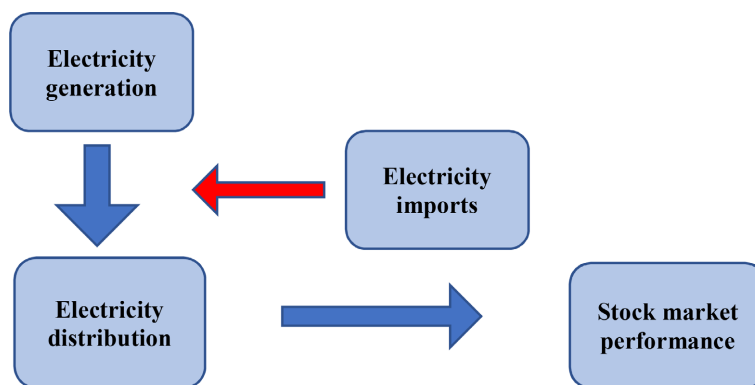
Source: Author's compilation (2023).

Figure 2. The mediating role of electricity imports (conceptual framework).

1.4.1. Electricity Generation, Distribution and Import Challenges

While electricity access has been reported to have increased in Botswana, with generation shortfalls met by imports, security of power supply has been identified as an imperative due to the challenges faced by Botswana which include the substandard performance of the sole coal-fired generation infrastructure, an unreliable electricity import situation caused by regional shortfalls, and lack of independent power producers (IPPs) [3]. In the 2036 vision of the African Development Bank's (ADB) and country strategy to transform Botswana into a high-income country, generation, transmission, and distribution of clean power are one the three major activities alongside others dealing with water and transport.

1.4.2. Prosumers

The technical aspects of electricity generation are beyond the scope of this research, but the assumption (see Conceptual Framework in Figure 2) is that any shortfalls in electricity generation and demand by consumers are met by electricity imports to augment the total electricity distributed in the country. There are potential "prosumers" in the network, who are both *pro*ducers and con*sumers* [13] [14] with micro-generating capabilities, or huge local prosumers that might even be able to feed into the distribution network.

2. Prior Research

Theoretically, energy price fluctuations evidence, where energy is taken in a wide sense to include oil, has been linked to aggregate economic activity so as to inform policy [15]. Some of these economic theories and models include "*Classic Supply-Side Shock*", "*Income Transfers and Aggregate Demand*", and the "*Real Balance Effect*" [15]. Income Transfer, whereby purchasing power shifts from oil importing nations to oil-exporting nations, reducing customer demand, was found to explain both situations as observed, inasmuch as monetary policy can partly balance out the effect of the reduction in aggregate demand. Botswana is an oil importing nation, in as far this is a form of energy, and additionally imports electricity energy so the theories by [15] can be assumed to hold for the

country.

Market capitalization is a function of quantities of stocks or shares and prices of listed equities [16], in 17 advanced economies studied, [16] found that long-run stock market growth as far back as the 1870 to the 1980s was driven by issuances and trends showing market capitalisation growing in line with GDP, whereas recent expansion has been attributed to rising prices, showing a structural break caused by profit, with firm profit and capital income doubling to all-time highs in 146 years. Other economic and firm level research linked to market capitalisation involved using time series forecasting for the Standard and Poor (S&P 2500) through financial turbulence with autoregressive models, moving averages and normal Dynamic Linear Model [17]

2.1. Electricity Energy and Economy Research

Some research approaches on the impact and relationship among energy price (shocks), the stock market and the macroeconomy at country and economy level in China, Mexico and Indonesia has found evidence that when crude oil prices rise, as measured both by the West Texas Intermediate (WTI) and Brent, fluctuations in the international market arise and cause energy price rises for coal and electricity and general decrease in economic growth [18] [19] [20] [21]. Using auto-regression, [18] found that a mere 1% rise in the energy price index can cause a depression in the stock market index by 0.54%. Benefits of private participation in renewable energy have been researched in Ghana [22]. While some of the approaches focused on prices, the approach in this research will go back in the value chain to actual production and employ electricity generation and distribution statistics to investigate what impact and effect these have on stock market performance.

2.2. Stock Market Research in Africa

Research on stock markets in Africa has focused on the comparative stock market response to Covid-19 in Botswana and Ghana [9]. Budget deficits as a macro indicator were used to assess the performance of stock markets in Africa over a period from January 2000 to December 2017 [23]. Using data from the World Bank Development Indicators, the Association of Security Exchanges in Africa and International Monetary Fund Statistics while holding other factors constant, increases in budget deficit were found to have had negative effect on stock market performance.

2.3. Energy (Including Electricity) Empirical Research

Data envelopment analysis using linear programming has been used to investigate the efficiency of large numbers of 41 individual electricity generating and distribution companies with respect to their technical or allocative efficiency linked to their profitability and own stock market performance [24] over a period of five years, while electricity consumption, and perhaps not necessarily

distribution, was found to be strongly correlated to economic activity, albeit disturbed by natural disasters and Covid-19, with daily consumption data in Bangladeshi [25]. Electricity price changes were found to have an asymmetric relationship to the Borsa Istanbul 100 index and its sub-sector indexes using non-linear autoregressive log models over a period from June 2006 to February 2008 [14].

On the African continent, and for Botswana in particular, energy consumption and generation trends over 13 years were used to try and forecast demand to check if the planned installed capacity increase to 1332 MW, would satisfy the country's energy demand with 100% access [26]. As far back as 2014 the significant increase of imports and/or load shedding to meet demand was forecast.

This research intends to add to this research from a separate perspective to come up with a model to forecast stock market performance in the as yet unreported 4 quarters of 2022, as measured by market capitalisation, from power distribution trends. This "*benefit of hindsight*" is occasioned by the already substantial mediating effect of imported electricity (see Conceptual Framework in Figure 2). The current proportion of physical volume of imported electricity in Botswana as a percentage of physical volume of electricity distributed is 25% (1,091,768 MWH/ 4,265,164 MWH) for 2022 with Eskom (South Africa) accounting for 42% of this in the Fourth Quarter of 2022 [7].

3. Methodology

The methodology employed for this research is simple regression modelling. A total of 40 samples of data paired by corresponding year and quarter from 2012 to 2021 was collected from independent sources [7] [8].

3.1. Introduction and Overview of Independent Sources

The Botswana Stock Exchange (BSE) is the sole stock exchange for Botswana mandated to operate and regulate the securities market in the country. It was initially set up in 1989, transformed by legislation into a full exchange in 1994 and demutualised in December 2018 from its prior set up of ownership by stockbroker members into a for-profit public company limited by shares and registered under the Companies Act owned by the government of Botswana. The BSE is affiliated with the World Federation of Exchanges (WFE), is partnered with the United Nation's Sustainable Stock Exchange (SSE) initiative and a recognised exchange under the United Kingdom's His Majesty's Revenue and Customs (UK HMRC). It operates 1) a main board; 2) venture capital market board; 3) exchange traded funds board (EFT board); 4) government and quasi-government boards board; 5) over the counter (OTC) board; 6) exchange traded fund (ETF) board with securities. The HMRC classifies the BSE as a "whole market" [8].

Statistics Botswana is an autonomous parastatal organisation with roots in the Central Statistical Office prior to a change in law (Statistics Act of 2009). It is mandated to collect, process, analyse, publish, and disseminate official statistics

on all sectors of Botswana as well and to develop and maintain a national database that can facilitate statistical analysis, among other duties, in addition to coordinating the National Statistical System (NSS) [7]. It is thus the foremost authority and source of official statistics in the country.

3.2. Modelling Procedure

The procedure outlined below was followed to come up with a regression model for predicting total stock market capitalization from available electricity distribution statistics. Table 1 shows the description and measurement of variables.

Step 1:

Regression analysis—Simple linear regression

Simple linear regression is a model with a simple explanatory variable, that is,

$$y = \beta x + a$$

where:

y = response (dependent) variable

β = slope (or coefficient)

x = predictor (independent) variable

a = estimated intercept/constant term (or y-intercept)

For the purpose of this research these are respectively, y = total market capitalisation, and x = electricity distribution.

Table 1. Description and measurement of variables.

Variable	Code	Treatment	Description
Independent Variable	ElecDistMWH	Not inputted directly into SPSS	Electricity Distribution (mega-watt hour)
Dependent Variable	TMCPm	Not inputted directly into SPSS	Actual Total Market Capitalisation (Pm)
Dependent Variable	TMCPmLN	Input directly into SPSS	Market Capitalisation (Pm) natural log
Independent Variable	ElecDistMWHLN	Input directly into SPSS	Electricity Distribution (mega-watt hour) natural log
	EstimatedTMCPmLN	$y = \beta x + a$	Estimated Total Market Capitalisation (Pm) natural log. For estimation after regression
	EXP of TMCPmLN	Derived from applying $y = \beta x + a$	Exponential of Total Market Capitalisation natural log
	Actual TMCPm	Input into	Actual Total Market Capitalisation (Pm)
	Pm	Not inputted directly into SPSS	Millions of Pula (Botswana currency)
	MWH	Not inputted directly into SPSS	Mega Watt Hours
	LN	Applied to TMCPm And ElecDistMWH in MS Excel	Natural log function of MS Excel
	EXP	Applied to EstimatedTMCPmLN in MS Excel	Exponential function of MS Excel

Source: Author's compilation (2023).

Assumptions

To assist in carrying out the regression modelling, assumptions made are as follows:

1) The dependent and independent variables should be measured at the continuous level, in that they should be interval or ratio variables.

2) A linear relationship between the two variables, as measured by correlation, should not be zero.

3) Data used should show homoscedasticity, meaning that the variances in the data along the line of best fit should remain similar when moving along the line.

4) Data must have independence of observations.

5) No significant outliers should be in the data so as to protect the residual and make the prediction outcome valid and lastly.

6) The residuals (or errors) of the regression should be approximately normally distributed.

Data is tested (see datasets in **Appendix 2** and **Appendix 3**) with a sample size of 40 pairs (n = 40) of independently observed and recorded data by the Botswana Stock Exchange and Statistics Botswana over matching quarters in the ten-year period from 2012 to 2021.

Step 2:

The tests for assumptions 1, 2 and 3 above were performed outside of the actual regression analysis procedure.

Step 3

Assumptions 4, 5 and 6 were performed simultaneously with the regression analysis.

Predictive Modelling

Predictive modelling can therefore be carried out to use available data for **y** and **x** to determine the slope and the constant term **a** (**y** intercept) to come up with a useful model to predict changes in electricity distribution and how they influence total market capitalisation.

To test assumption 4, generally, independence of observations is tenable if the Durbin-Watson test is not less than 1 or greater than 3. In most cases, the minimum standardised residuals should not be less than −3.39 and the maximum standardised residual should not be greater than +3.29.

No outliers were found, and the case-wise diagnostics table was not produced. Therefore, assumption number 5 is satisfied and tenable. Assumption number 6 was tested by using the histogram and P-P plot. The histogram and normal curve look like a bell curve as shown in Figure 3.

The histogram helps to determine if the size of the residual is constant across the entire dataset or not.

The histogram of regression standardised residuals with an embedded normal curve shown is used to determine whether the regression residual or error associated with the model is approximately normally distributed or not. This is meant to satisfy assumption number 6 above. From a visual inspection of the histogram and curve, there is an appropriate approximation of normal distribution
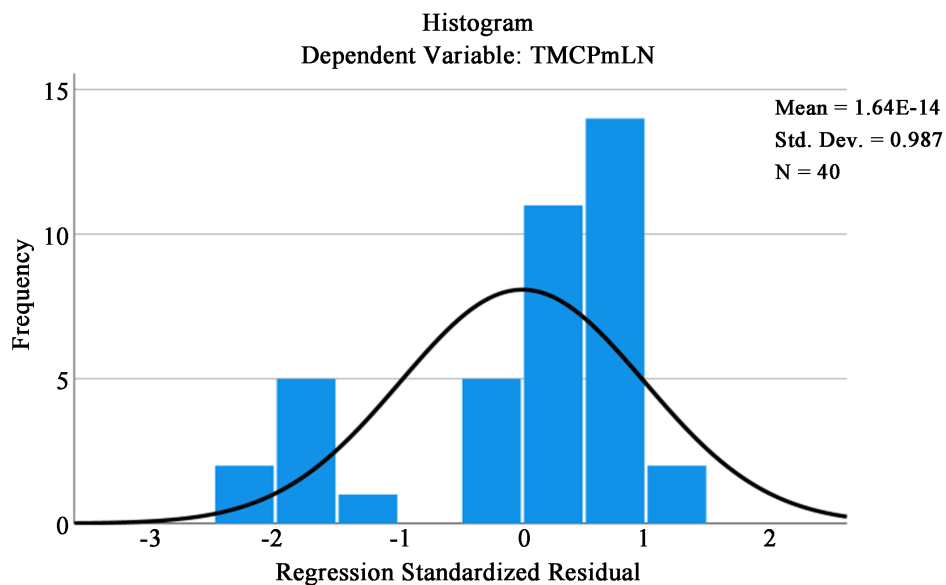
Figure 3. Histogram.

on the regression residual.

The P-P plot is meant to compare the distribution of data in several theoretical models [27]. Approximate fit of data to the y = x line is ideal, to show through the plot that distributions of data are symmetrical according to their kurtosis, meaning that the treatment (independent) variable distribution and the control (independent) distribution, have both been transformed to a scale that shows distribution uniformity on the unit interval [27] [28].

Where there is visual similarity to a distribution that is uniform, there is a suggestion that data is well truncated, meaning that both small and large values have been excluded. The data points in the P-P plot in **Figure 4** show very close distribution along the 45-degree curve. This was partly assured by use of natural logs (LN) to remove large and small values.

Unlike wide belief, the homoscedasticity assumption is more crucial in assessments of normality of validity of ANOVA [29]. The size of the residual does appear constant across the dataset (**Figure 5**).

3.3. Presentation of Findings and Interpretation

Table 2 below shows that mean of total market capitalization at LN value is 12.9278 while the mean of the electricity distributed (LN value) is 13.7760 with standard deviations of 0.02675 and 0.05861 respectively (n = 40).

There is no significant relationship between electricity distribution and market capitalisation when using correlations. (**Table 3**)

The r = −0.094 is showing a negative relationship between the dependent and the independent variables. While a Pearson correlation analysis can be used to understand the relationship among and between variables [30], this is not ideal for modelling or making conclusions in this case.

Table 4 confirms that, the only predictor in the model is confirmed as

Normal P-PPlot of Regression Standardized Residual
Dependent Variable: TMCPmLN

Figure 4. P-P plot.

Scatterplot
Dependent Variable: TMCPmLN
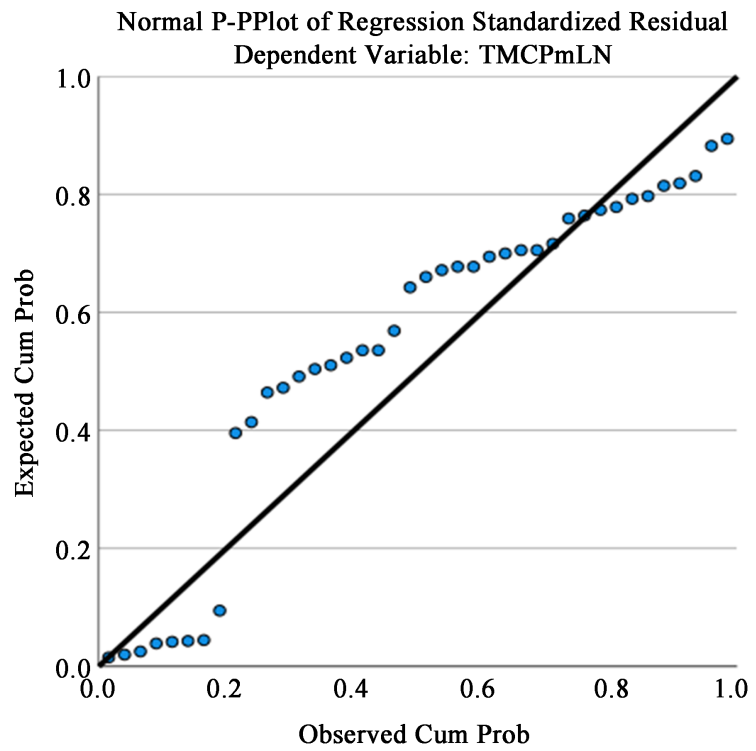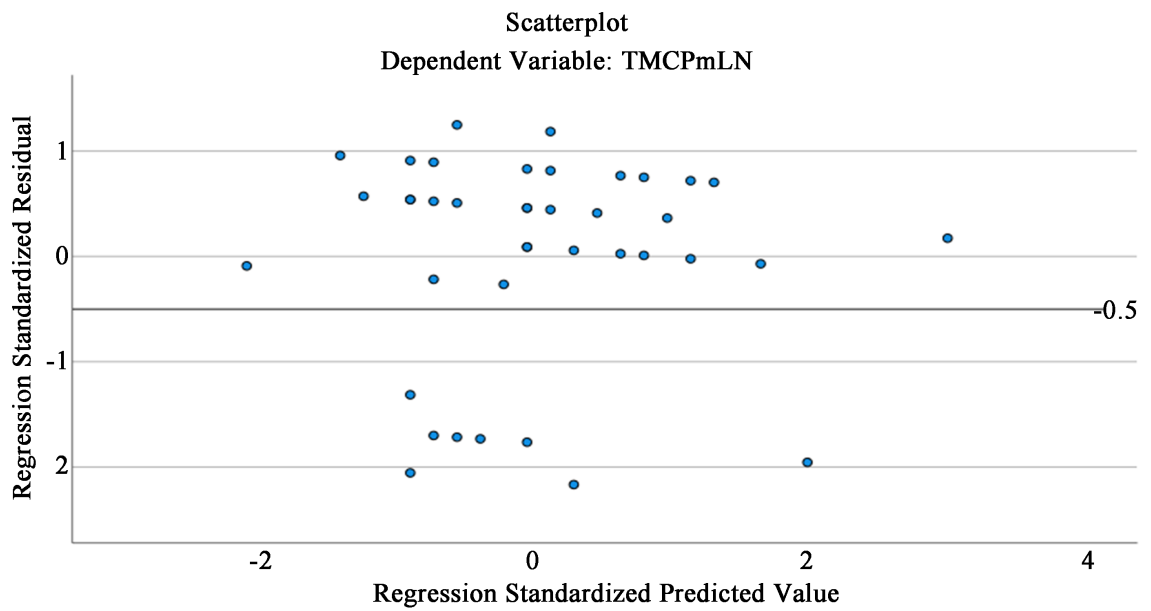
Figure 5. Scatter plot.

Table 2. Descriptive Statistics.

Descriptive Statistics			
	Mean	Std. Deviation	N
TMCPmLN	12.9278	0.02675	40
ElecDistMWHLN	13.7760	0.05861	40

Table 3. Correlations.

Correlations			
		TMCPmLN	ElecDistMWHLN
Pearson Correlation	TMCPmLN	1.000	−0.094
	ElecDistMWHLN	−0.094	1.000
Sig. (1-tailed)	TMCPmLN		0.282
	ElecDistMWHLN	0.282	
N	TMCPmLN	40	40
	ElecDistMWHLN	40	40

Table 4. Variables entered/removed.

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	ElecDistMWHLN[b]		Enter

[a]Dependent Variable: TMCPmLN; [b]All requested variables entered.

electricity distributed (after conversion to a natural log) and that the method applied was enter, with the dependent variable being total market capitalisation (converted to a natural log).

All requested variables requested were entered.

4. Findings and Discussion

The section below discusses the findings, starting with the model summary, then moving on to the residual statistics, analysis of variance (ANOVA), and coefficients, leading to the conclusions that are drawn from the findings.

4.1. Model Summary

Generally, independence of observations is able to be maintained if the Durbin-Watson test result is not less than 1 or greater than 3 [31]. The Durbin-Watson statistic (d = 0.119) is less than 1, which implies that the assumption that the data on total market capitalisation and electricity generation have independence of observations.

The Durbin-Watson statistic detects first order autocorrelation in a series, and it is important, in model building, to stress the assumptions employed [31]. General assumptions on the items and issues that were not considered in this research, together with specific assumptions on the model being build have been stated.

Nonetheless, because the bodies charged with collecting and reporting stock market capitalisation [7] and electricity generation statistics [8] are independent legal entities, the tenability of the assumption of independence of observation is nonetheless upheld. In addition, Statistics Botswana does not itself distribute

electricity.

As shown in Table 5, the R is = .094 (as the correlation) while the adjusted R^2 is −0.017 (converted to a % as −1.7%). This low adjusted R-squared might make the regression model questionable as to whether it is a good fit and representation of the variable, nonetheless, more robust methods that could factor in any effects of outliers are covered in the proposed further research section below.

The residual statistic in Table 6 shows that the minimum standardised residual is −2.166, which is not below the lower limit of −3.29. The maximum standardised residual is 1.250 which is not above the upper limit of +3.29.

4.2. Robustness Test

To ascertain whether the result of the regression analysis is reliable, a follow-up

Table 5. Model summary.

				Model Summary[b]		
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.094[a]	0.009	−0.017	0.02697	0.119

[a]Predictors: (*Constant*), ElecDistMWHLN; [b]Dependent Variable: TMCPmLN.

Table 6. Residual Statistics. As outlined in the assumptions above, the minimum standardised residual should not be less than −3.39 with a maximum of standardised residual not greater than +3.29.

	Residuals Statistics[a]				
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	12.9224	12.9353	12.9278	0.00252	40
Residual	−0.05844	0.03371	0.00000	0.02663	40
Std. Predicted Value	−2.116	3.003	0.000	1.000	40
Std. Residual	−2.166	1.250	0.000	0.987	40

[a]Dependent Variable: TMCPmLN.

Table 7. ANOVA. The ANOVA table below (F = 0.340, p-value of 0.563), shows that the F statistic indicates an insignificant correlation between the dependent variable and the independent variable. (Table 7)

		ANOVA[a]				
	Model	Sum of Squares	df	Mean Square	F	Sig.
	Regression	0.000	1	0.000	0.340	0.563[b]
1	Residual	0.028	38	0.001		
	Total	0.028	39			

[a]Dependent Variable: TMCPmLN; [b]Predictors: (Constant), ElecDistMWHLN.

test to check robustness of the model and analysis was conducted. ANOVA is not applied to evaluate the robustness of the model in this case since unless there is a small sample size, some suggestions are that n = 50 or less, normality can be ignored when applying ANOVA [29].

Nonetheless, the hypotheses applicable to this regression are:

Null hypothesis—there is no linear relationship between total market capitalization and electricity distribution measures.

Alternative hypothesis—there is a linear relationship between total market capitalization and electricity distribution.

From the above, the most crucial value in the ANOVA table above is the significance value. The ranges for the p-value are (at 95% confidence level) p less than or equal to 0.05 which is adequate to reject the null hypothesis and accept the alternative hypothesis.

If the p value is greater than 0.05, the null hypothesis should be accepted and the alternative hypothesis rejected. The result of value p = .563 is greater than the p-value 0.05 so the null hypothesis should be accepted (Table 8). In other words, there is no linear relationship between total market capitalization and electricity distribution, since,

$$\beta = -0.043$$
$$a = 13.520$$

5. Conclusions

The model planned for predicting total market capitalisation using electricity generation statistics was

$$y = \beta x + a$$

where:

y = response (dependent) variable
β = slope (or coefficient)
x = predictor (independent) variable
a = estimated intercept/ constant term (or y-intercept)

From the findings above this means, therefore, that;

Table 8. Coefficients.

		Coefficients[a]						
	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	13.520	1.015		13.316	0.000	11.465	15.575
	ElecDistMWHLN	−0.043	0.074	−0.094	−0.583	0.563	−0.192	0.106

[a]Dependent Variable: TMCPmLN.

β = slope (or coefficient) is = -0.043

a = estimated intercept/ constant term (or y-intercept) is = 13.520

$$y = \beta x + a$$

Such that

$$y = -0.043x + 13.530$$

The prediction model above can be applied to predict total market capitalisation under the same general (research and data) and specific simple regression modelling assumptions as above in the procedure outlined.

5.1. Practical Implications

The result above can be used to predict market capitalisations for Q1 - Q4 for 2022 which were not yet published at the time of writing. Employing the inverse of the natural logarithm and using the exponential function in MS Excel (the EXP function), and applying the regression model above, the prediction for Quarters 1 of the 2022 Botswana Stock Exchange (BSE) was predicted to be Pm410,732.37 (see **Appendix 1** and **Appendix 2**).

By substituting the formula

$$y = -0.043x + 13.530$$

We find that (using the natural log of electricity distribution for Q1 of 2022, which was 1,005,505 MWH) [7].

$$y = -0.043 \times 13.82 + 13.530$$

$$y = -0.59 + 13.530$$

$$y = 12.93$$

Also see **Appendix 1** below. As this is based on a natural log (LN), reversal of the log is required. The exponential (EXP) of the natural log (LN) 12.93 is 410,732.37 being the target independent variable of total market capitalisation in (Pm) for Q1 of 2022 (P410,732.37 m). This is then compared to the actual recorded and reported market capitalisation of P 388,177.6m and repeated for the 2022 data for Quarters 2 through 4 with data now available at the time of publication.

This compares very well to the predicted value of market capitalisation from the model with a variance of only −P22,389.53m (or 5.77% rounded up to 6% for Quarter 1 of 2022 when the variance is expressed as a percentage of the actual [8], or 5.45% as a percentage of the predicted total market capitalisation.

At the time of finalising the research, the BSE annual report for 2022 was not yet out, an update became available at the time of publishing [8], allowing a comparison the total market capitalisation of the BSE for the four quarters in 2023 to a similar period for 2022 (see **Appendix 1**).

5.2. Research Contributions

In the context of a developing and emerging economy in Sub-Saharan Africa, market capitalisation and electricity distribution have not been researched and modelled with regression analysis prior. The predictive statistical analysis in this

paper highlights a research theme that is relatively novel and niche. On reflection, in attempting to introspect, the author looked through their prior work experience working for an electricity generating company and their professional accountancy training, including some working knowledge of statistics, but the thought processes that must have been at play are captured eloquently by [32]. Through a comprehensive integrative review of literature, they highlight the tensions individuals experience in coming up with novel, useful and implementable ideas while bringing some uniqueness to their endeavours. The section below suggests some theoretical and research implications and suggested future research.

5.3. Theoretical/Research Implications

Some theoretical and research implications arising from this research are that a relationship between electricity distribution in an economy is a variable macro-economic indicator that can be used to model another macro-economic indicator of performance (total stock market capitalization). While the statistical model developed uses only simple regression, more robust and sophisticated analysis that holds fewer factors that influence the target variable, total market capitalisation constant, could be modelled with finer-grained independent sources of data with more data points for analysis and modelling.

5.4. Suggested Future Research

Future research could focus on a finer-grained analysis of high-energy demanding companies, perhaps in the mining, energy, manufacturing sectors and how their relative electricity demand might be indicative of a more nuanced link between electricity generation and distribution and economic activity in the extractive and manufacturing sectors as measured by their sectoral market capitalisation.

The use of Median Absolute Deviation (MAD) is suggested. MAD is a robust measure of dispersion that is less affected by outliers compared to traditional measures like standard deviation [33]. MAD is calculated as the median of the absolute deviations from the median. Outliers can be identified as data points that fall beyond a certain threshold, as a multiple of the MAD. Other methods that could be attempted are the trimmed mean with boxplots analysis. An alternative could be use of a trimmed mean which is calculated by excluding a certain percentage of extreme values from both ends of the data distribution [4] [5]. This approach reduces the influence of outliers on the mean estimate, making a more robust model. The percentage of data to be trimmed would depend on the specific characteristics of the data and the desired level of robustness. Boxplots that provide a visual representation of the data distribution, including information about the median, quartiles, and any outliers [5] have been used above. A few outliers were identified as data points that fall outside the whiskers of the boxplot, which typically extend a certain number of interquartile ranges (IQR)

from the lower and upper quartiles. Boxplots help in detecting outliers and understanding the spread and symmetry of the data.

Another suggestion for future research is to include Price/Earnings (P/E (x) ratios, Dividend Yield (%), and/or Price/Book Value (x) in the model as this might be a proxy indicator of the importance of listed companies to the general economic output as perceived by the demand for their shares by the investing public. These indicators of value statistics are provided by the BSE and for the P/E ratio particularly for example, for the market, the BSE computes this by dividing market capitalisation by total earnings (profits) of listed companies [8]. Monthly contributions to the BSE market capitalisation can also be used with the electricity generating statistics to check the findings of this research using more data points.

5.5. Limitations

The paper used the overall Botswana stock market performance and did not attempt to exclude listed companies that might have a lower reliance on electricity generation and distribution. Service companies that are listed on the BSE include banks, insurance companies, supermarkets/ retailers (domestic), while the foreign counter includes financial services providers, sales, merchandising, warehousing, distribution, and debtors' services providers. The distinction on type of company and their relative electricity demand was not attempted. The limitations above do not affect the relevance and applicability of the findings in this study as simple regression was attempted, without adding more variables as for multiple regression and also that the findings are explorative of a research area and relationship that has not, prior to this research, been attempted.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Vumbunu, T., Viviers, P.-A. and Du Plessis, E. (2022) Trends and Development of Tourism Product Diversification in Botswana: Lessons Learned. *Journal of Environmental Management and Tourism*, **13**, 1016-1035.
https://doi.org/10.14505/jemt.v13.4(60).09

[2] Schiliro, D. (2022) Botswana's Economy and the Question of Diversification. Munich Personal RePEc Archive (MPRA), MPRA Paper No. 115608.

[3] African Development Bank Group (2022) Bank Group Country Strategy Paper 2022-26-Republic of Botswana. Revised Version, RDGS/ECCE (March 2022). 1-22.
https://www.afdb.org/en/documents/botswana-bank-group-country-strategy-paper-2022-2026

[4] Welsh, A. (1987) The Trimmed Mean in the Linear Model. *The Annals of Statistics*, **15**, 20-36. https://doi.org/10.1214/aos/1176350248

[5] Najdi, N.F.N. and Ahad, N.A. (2019) Modification of ANOVA with Trimmed Mean. *Malaysian Journal of Social Sciences and Humanities* (*MJSSH*), **4**, 109-118.

[6] International Renewable Energy Agency (IRENA) (2021) Renewables Readiness

Assessment Botswana. 1-94.
https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Aug/IRENA_RRA_Botswana_2021.pdf

[7] Statistics Botswana (2014-2022) Electricity Generation and Distribution, Stats Brief. Fourth Quarter 2022. https://www.statsbots.org.bw/latest-publications

[8] Botswana Stock Exchange (2012-2022) Annual Reports. https://www.bse.co.bw/annual-reports

[9] Tetteh, J.E., Amoah, A., Ofori-Boateng, K. and Hughes, G. (2022) Stock Market Response to COVID-19 Pandemic: A Comparative Evidence from Two Emerging Economies. *Scientific Africa*, **17**, e01300. https://doi.org/10.1016/j.sciaf.2022.e01300

[10] Williamson, D.F., Parker, R.A. and Kendrick, J.S. (1989) The Box Plot: A Simple Visual Method to Interpret Data. *Annals of Internal Medicine*, **110**, 916-921. https://doi.org/10.7326/0003-4819-110-11-916

[11] Castro, G.M., Klöckl, C., Regner P., Schmidt, J. and Pereira Jr., A.O. (2022) Improvements to Modern Portfolio Theory Based Models Applied to Electricity Systems. *Energy Economics*, **111**, Article ID: 106047. https://doi.org/10.1016/j.eneco.2022.106047

[12] Lerede, D. and Savoldi, L. (2023) Might Future Electricity Generation Suffice to Meet the Global Demand? *Energy Strategy Reviews*, **47**, Article ID: 101010. https://doi.org/10.1016/j.esr.2023.101080

[13] Kumar, S.V., Prasad, J. and Samikannu, R. (2018) Barriers to Implementation of Smart Grids and Virtual Power Plant in Sub-Saharan Region—Focus Botswana. *Energy Reports*, **2**, 119-128. https://doi.org/10.1016/j.egyr.2018.02.001

[14] Turhan, B. and Doğan, N. (2021) Electricity Prices and Stock Market Performance: Evidence from Borsa Istanbul. *Journal of Sustainable Economics and Management Studies*, **2**, 41-55.

[15] Brown, S.P.A. and Yücel, M.K. (2002) Energy Prices and Aggregate Economic Activity: An Interpretative Survey. *The Quarterly Review of Economics and Finance*, **42**, 193-208. https://doi.org/10.1016/S1062-9769(02)00138-2

[16] Kuvshinov, D. and Zimmermann, K. (2021) The Big Bang: Stock Market Capitalization in the Long Run. *Journal of Financial Economics*, **145**, 527-552. https://doi.org/10.1016/j.jfineco.2021.09.008

[17] Souto, H.G. (2023) Time Series Forecasting Models for S&P 500 Financial Turbulence. *Journal of Mathematical Finance*, **13**, 112-129. https://doi.org/10.4236/jmf.2023.131007

[18] Cong, R.-G. and Shen, S. (2013) Relationships among Energy Price Shocks, Stock Market, and the Macroeconomy: Evidence from China. *The Scientific World Journal*, **2013**, Article ID: 171868. https://doi.org/10.1155/2013/171868

[19] Gaol, Y.L. and Faturohman (2016) Relationship between Crude Price and Indonesia Stock Market. *Journal of Business and Management*, **5**, 510-517.

[20] Kesikoğlu, F. and Yıldırım, E. (2014) The Causal Effect of Shifting Oil to Natural Gas Consumption on Current Account Balance and Economic Growth in 11 OECD Countries: Evidence from Bootstrap-Corrected Panel Causality Test. *Procedia—Social and Behavioral Sciences*, **143**, 1064-1069. https://doi.org/10.1016/j.sbspro.2014.07.556

[21] Uri, N.D. and Boyd, R. (1997) An Evaluation of the Economic Effects of Higher Energy Prices in Mexico. *Energy Policy*, **25**, 205-215. https://doi.org/10.1016/S0301-4215(96)00126-7

[22] Afful-Dadzie, A., Mensah, S.K. and Afful-Dadzie, E. (2022) Ghana Renewable Energy Master Plan: The Benefits of Private Sector Participation. *Scientific African*, **17**, e01353. https://doi.org/10.1016/j.sciaf.2022.e01353

[23] Mwinaayelle, S.D.-U. (2023) Budget Deficits and Stock Market Performance in Emerging and Frontier Markets in Africa. *Open Access Library Journal*, **10**, e9602. https://doi.org/10.4236/oalib.1109602

[24] Gurgen, E. and Norsworthy, J.R. (2001) Efficiency and Stock Market Performance in Electric Power Generating Companies. *IEMC'01 Proceedings. Change Management and the New Industrial Revolution*, Albany, 7-9 October 2001, 412-420. https://doi.org/10.1109/IEMC.2001.960576

[25] Arshad, S. and Beyer, R.C.M. (2023) Tracking Economic Fluctuations with Electricity Consumption in Bangladesh. *Energy Economics*, **2023**, Article ID: 106740. https://doi.org/10.1016/j.eneco.2023.106740

[26] Essah, E.A. and Ofetotse, L. (2014) Energy Supply, Consumption and Access Dynamics in Botswana. *Sustainable Cities and Society*, **12**, 76-84. https://doi.org/10.1016/j.scs.2014.01.006

[27] Meloun, M. and Militký, J. (2011) The Exploratory and Confirmatory Analysis of Univariate Data. In: Meloun, M. and Militký, J., Eds., *Statistical Data Analysis*, Woodhead Publishing India, New Delhi, 25-71. https://doi.org/10.1533/9780857097200.25

[28] Dewan, I. and Kochar, S. (2013) Some New Applications of P-P Plots. *Probability in the Engineering and Informational Sciences*, **27**, 353-366. https://doi.org/10.1017/S0269964813000077

[29] Yang, K., Tu, J. and Chen, T. (2019) Homoscedasticity: An Overlooked Critical Assumption for Linear Regression. *General Psychiatry*, **32**, e100148. https://doi.org/10.1136/gpsych-2019-100148

[30] Olatunde, P.S., Philiphs, I.M., Juliano, A.Y. and Imhansoeleva, T.M. (2015) Geochemical and Statistical Approach to Assessing Trace Metal Accumulations in Lagos Lagoon Sediments, South Western, Nigeria. *Journal of Geography, Environment and Earth Science International*, **3**, JGEESI.20333. https://doi.org/10.9734/JGEESI/2015/20333

[31] Champion, R., Lenard, C.T. and Mills, T.M. (1998) Demonstrating the Durbin Watson Statistic. *Journal of the Royal Statistical Society, Series D (The Statistician)*, **47**, 643-644. http://www.jstor.org/stable/2988366 https://doi.org/10.1111/1467-9884.00161

[32] Potocnik, K., Verwaeren, B. and Nijstad, B. (2022) Tensions and Paradoxes in Creativity and Innovation. *Journal of Work and Organisational Psychology*, **38**, 149-163. https://doi.org/10.5093/jwop2022a19

[33] Elsayed, E. (2012) Mean Absolute Deviation about Median as a Tool of Explanatory Data Analysis. *International Journal of Research and Reviews in Applied Sciences*, **11**, 517-523.

Appendix 1. Estimated Total Market Capitalisation of the BSE for Q1 of 2022

Year	2022			
Quarter	Q1	Q2	Q3	Q4
ElecDistMWH	1,005,502	1,099,937	1,075,525	1,084,200
EstimatedTMCPmLN	12.93	12.92	12.92	12.92
ElecDistMWHLN	13.82	13.91	13.89	13.90
β	−0.043	−0.043	−0.043	−0.043
a	13.520	13.520	13.520	13.520
EXP of TMCPmLN	410,732.37	409,150.02	409,545.08	409,403.63
Actual TMCPm	388,342.84	387,840.51	392,072.33	394,203.36
Variance	22,389.53	21,309.51	17,472.75	15,200.27
Variance % (absolute variance over actual)	5.77%	5.49%	4.46%	3.86%
Variance % (absolute variance over predicted)	5.45%	5.21%	4.27%	3.71%
When forecast	At time of writing	At time of publication		

The model

$$y = -0.043x + 13.530$$

is applied first to the natural logs (LN) as follows for Quarter 1 of 2022

$$y = -0.043 \times 13.82 + 13.530$$

yielding $y = -0.59 + 13.530$

resulting in $y = 12.93$ (natural log)

then using the Microsoft Excel exponential function **= EXP (12.925697)** to 6 decimal places yielding Pm**410,732,37** (total predicted market capitalisation in Pula (millions). This is then repeated for the remaining 3 quarters of 2023 above showing variances between predicted and actual capitalisation lower than 6% across all the remaining quarters.

Key: ElecDistMWH—Electricity Distribution (mega-watt hour); EstimatedTMCPmLN—Estimated Total Market Capitalisation (Pm) natural log; ElecDistMWHLN—Electricity Distribution (mega-watt hour) natural log

The symbols below are as per the regression formula/findings above

β = slope (or coefficient) = −0.043

a = estimated intercept/constant term (or y-intercept) = 13.520

EXP of TMCPmLN—Exponential of Total Market Capitalisation natural log
Actual TMCPm—Actual Total Market Capitalisation (Pm)
Pm—millions of Pula (Botswana currency)

Appendix 2. Electricity Distribution Dataset

Year	Physical Volume of Electricity Distribution (MWH)			
	Q1	Q2	Q3	Q4
2012	907,468	922,411	930,854	942,277
2013	875,157	899,445	922,077	805,758
2014	933,451	1,006,850	1,036,387	1,013,192
2015	969,920	1,006,224	956,410	1,041,132
2016	967,364	955,040	994,600	1,011,684
2017	887,503	899,365	1,018,442	967,012
2018	959,650	992,212	1,004,249	963,235
2019	965,718	925,597	972,090	1,087,612
2020	1,011,335	853,636	993,552	983,328
2021	943,147	968,484	1,003,738	1,012,766
2022	1,005,502	1,099,937	1,075,525	1,084,200

Year	LN of Physical Volume of Electricity Distribution			
	Q1	Q2	Q3	Q4
2012	13.72	13.73	13.74	13.76
2013	13.68	13.71	13.73	13.60
2014	13.75	13.82	13.85	13.83
2015	13.78	13.82	13.77	13.86
2016	13.78	13.77	13.81	13.83
2017	13.70	13.71	13.83	13.78
2018	13.77	13.81	13.82	13.78
2019	13.78	13.74	13.79	13.90
2020	13.83	13.66	13.81	13.80
2021	13.76	13.78	13.82	13.83
2022	13.82	13.91	13.89	13.90

Key: LN—natural log

Appendix 3. Total Market Capitalisation Distribution Dataset

Year	Total Market Capitalisation (Pm)			
	Q1	Q2	Q3	Q4
2012	415,030.80	422,826.20	422,839.20	412,349.00
2013	412,786.00	414,248.40	413,241.10	416,590.40
2014	415,812.92	418,219.81	418,082.39	418,156.71
2015	415,697.23	421,133.37	419,037.18	421,099.18
2016	419,820.61	425,645.03	425,625.02	421,313.19
2017	419,729.50	420,563.12	417,013.55	418,143.76
2018	416,605.07	415,185.26	410,401.67	413,168.28
2019	412,428.60	410,742.50	408,143.60	407,874.20
2020	395,633.67	393,446.81	391,801.95	391,222.12
2021	389,961.12	390,525.45	391,308.50	390,365.76
2022 #	*1,005,502*	*1,099,937*	*1,075,525*	*1,084,200*

Year	LN of Total Market Capitalisation			
	Q1	Q2	Q3	Q4
2012	12.94	12.95	12.95	12.93
2013	12.93	12.93	12.93	12.94
2014	12.94	12.94	12.94	12.94
2015	12.94	12.95	12.95	12.95
2016	12.95	12.96	12.96	12.95
2017	12.95	12.95	12.94	12.94
2018	12.94	12.94	12.92	12.93
2019	12.93	12.93	12.92	12.92
2020	12.89	12.88	12.88	12.88
2021	12.87	12.88	12.88	12.87
2022 ##	*12.93*	*12.92*	*12.92*	*12.92*

Key: LN—natural log; Pm—millions of Pula (Botswana currency). **#**—actual; **##**—these were not available (at the time of writing) but became available at the time of publication.