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Trivariate Modelling of the Nexus Between Financial Development, Globalization and Economic Growth: Insight from African Countries

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Abstract

Financial development has been identified as main drivers of economic growth. However, empirical probe of this nexus remains inconclusiveness due use of an inappropriate proxy by previous studies, and the inability of previous studies to consider globalization in this nexus. To this end, we probe the finance-growth nexus in the presence of globalization by applying the Pooled Mean Group (PMG) estimator to a sample of 21 countries spanning 1990–2017. The empirical results affirm the supply-leading hypothesis which indicates that financial development spur economic growth. In addition, our estimate provides evidence of a positive linear relationship between globalization and economic growth. Further, results indicate that physical capital investment plays an important role in accelerating economic performance of African economies. Based on these findings, it is important for African countries to promote globalization-financial development policies in order to have access to alternative sources of external financing and attract foreign investment that can spur growth of African countries.

JEL Code: F60, G20, O40.

Keywords: Financial Development, Globalization, Economic Growth, Pooled Mean Group and African Countries.

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1. Introduction

The objective of every economy is to achieve sustainable economic development because economic progress is essential for poverty reduction and infrastructure development in the long run (Shahbaz, Nasir, Hille and Mahalik, 2020). Financial development accelerate growth by mobilizing savings, encourages resource allocation, and eases divergence and management of risk (Sahay *et al.*, 2015). Thus, a fully developed financial system fascinates investment, lowers information cost and enhances growth (Levine, 2005 and Ang, 2008a).

Theoretically, relationship between finance and economic growth has been a controversial issue as it has led to the establishment of three positions namely; supply-leading, demand-following and neutrality hypothesis. The supply-leading hypothesis posits that finance augment growth while the demand-following hypothesis contend that growth give rise to the demand for financial services and the neutrality theory speculates that no causation between finance and growth.

Globalization entails the process whereby corporations and government connect across the globe (Zaidi, Zafar, Shahbaz & Hou, 2019). It promotes economic growth by allowing international investors access to local financial markets, improving the quality of financial institutions, and enhancing economic integration through trade and financial flows (Mishkin, 2009; Kandil et al. 2015 and Atil et al., 2020). Rousseau and Sylla (2003) also asserts that globalization gives access to innovative products, investment, and new ideas which increases per-capita income in the host country.

In the existing literature, there are numerous studies with mixed results on the relationship between financial development and economic growth (Adeniyi, Oyinlola, Omisakin and Egwaikhide, 2015; Samargandi, Fidrmuc, and Ghosh, 2015; Kenza & Eddine, 2016; Muazu and Ibrahim, 2018; Botev and Jawadi, 2019; Alimi and Adediran, 2020; Wu *et al* 2020; and Redmond and Nasir, 2020). The present study contends that the divergent findings recorded could be because the authors did not account for globalization in their regressions. In addition, existing empirical studies have used a single indicator to examine the finance-growth nexus. Due of complex nature of services provided by the financial system, capturing financial development with a single indicator could lead to potential bias and mislead the outcomes. To this end, this study employs financial development index of World Bank Global Financial Development index and KOF index which entails economic, social and political aspects of globalization to probe the link among financial development, globalization and economic growth in African economies. Given the motivation around the attainment of economic development, there is need to evaluate the distinctive role of financial development and globalization in African economies to help project the trend of economic performance. This empirical exercise is important to help reveal the source of economic development in African economies and guide finance and growth policies appropriately.

The rest of the paper is structured as follows. The next section takes a look at the empirical facts on globalization in finance-growth nexus. Section 3 present the methodology while section 4 focuses on result and discussion of finding and section 5 concludes the paper.

2. Literature Review.

Recently, the interlinkage amongst finance, globalization and economic growth has attracted great attention from scholars and policy makers. Among these is the study of Ahmed, Zhang and Cary (2021) which incorporated globalization and ecological footprint into finance-growth nexus in Japan employed ARDL and NARDL estimation technique with annual data from 1971 and 2016. Their finding established that positive and negative change to finance foster economic footprint while positive and negative changes to globalization lessening the footprint. For Malaysia, Ahmed *et al* (2019) applied ARDL and annual data for 1971 and 2014 to assay the nexus between globalization and the ecological footprint. They found that population density lessens ecological footprint while energy consumption and economic growth accelerate ecological footprint. The result further indicates globalization hampers ecological carbon footprint in Malaysia. On the nexus between ICT, globalization and Co2

emission, Ahmed and le (2020) applied CUP-FM estimation technique for 6 ASEAN countries over the period of 1996 and 2017. The empirical result of the study disclosed that ICT reduces co2 emission and thereby enhance environmental quality.

Focusing on ECOWAS countries, Alimi and Adediran (2020) examined finance-growth nexus by incorporating ICT diffusion using PARDL technique spanning 2005 and 2016. The study finds that financial development retards growth while the interactive effect of financial development and ICT diffusion accelerate the growth in ECOWAS region. The study of Muhammad *et al.* (2016) employed panel estimation technique and discovered that financial development foster GCC economies. For China, Japan and India using bootstrapping ARDL spanning 1960 and 2016, Wu *et al* (2020) validates the supply-leading and demand-following hypotheses for Japan and India but support the supply-leading theory in China. For 52 middle-income nations spanning the period of 1980 and 2008, Samargandi, Fidrmuc, and Ghosh (2015) discover an inverse link between finance and growth in the long run. Kenza & Eddine (2016) show that finance impede growth in MENA countries. Likewise, Adeniyi, Oyinlola, Omisakin and Egwaikhide (2015) indicates financial development hinders growth in Nigeria.

For 100 developed and developing countries, Botev and Jawadi (2019) shows that finance stimulate economic growth in developed countries but exact an insignificant influence in close economies. For SSA countries, Brueckner and Lederman (2015) probed the linkage between trade openness and growth. They report that greater openness to international trade augment economic growth in both short-run and long run. In the same region, Muazu and Ibrahim (2018) finds that financial development hinders SSA growth when financial sector development is not complemented by real sector growth. Examining 30 countries spanning 1990 and 2016, Redmond and Nasir (2020) incorporated natural resources, trade openness, institutional quality and international trade into finance-growth nexus. Their empirical finding reveals that natural resource abundance and trade openness promotes growth while international trade and financial development inhibits growth.

Recently, Atil *et al* (2020) considered the link between natural resources and financial development through globalization, oil price and economic growth in Pakistan spanning 1972 and 2017. The outcome of their study suggests that natural resources, economic growth and oil price aid financial development while globalization dampen financial development. By employing ARDL, FMOLS and DOLS estimation technique, Guan, Kirikkaleli, Bibi and Zhang (2020) also investigated the same nexus in the presence of human capital in China. Their empirical result validates the demand-following and resources curse hypotheses which suggests that natural resources impedes financial development whereas globalization and human capital foster financial development in China. Osei and Kim (2020) probed the contribution of foreign direct investment in finance-growth nexus for 62 middle- and high-income countries between 1987 and 2016. Their panel threshold methodology results suggested foreign direct investment improves economic growth but retards economic growth whenever financial development exceeds the threshold of 95%. For 40 African countries, Ibrahim and Sare (2018) explored the determinants of financial development and established that trade openness and human capital stimulates Africa's financial development.

Using a sample of 23 European countries spanning 1989 and 2016, Nasreen, Mahalik, Shahbaz and Abbas (2020) employed GMM estimation to analyze the linkage between Financial Globalization, Institutions, Economic Growth and financial sector development.

Their empirical finding indicates that financial globalization inhibits financial development while institutions support financial inflows and augment financial development in European countries. In a related study, Nasreen *et al.* (2015) explore the linkages between financial development, institutions, globalization and economic growth. The finding of the PVAR technique reveals that globalization promote financial development through financial reforms and thereby spur economic growth. With the aid of Westerlund panel cointegration test and annual data from 1984 to 2008, Law *et al.* (2015) assessed the nexus between globalization, institutional reforms and financial development in East Asian economies. The study discovered that globalization strengthen financial development via institutional reforms. However, in India, Shahbaz *et al.* (2018a) estimated the link between globalization, institutional quality, economic growth and financial development. The result of the study reveals that globalization and institutional quality have detrimental effects on financial development whereas economic growth accelerates financial development.

By applying panel cointegration and causality methodologies for 32 developing and developed countries, Kandil *et al.* (2015) examined the role of globalization (proxied by globalization index) on financial development. The empirical result of the study suggests that globalization hinders financial development while financial development spurs globalization by relaxing the of constraints of external financing. Further, Kandil *et al.* (2017) probe the influence of globalization in the finance-growth nexus in China and India. The outcome of their study shows that globalization spurs economic growth in India but hampers growth in China. Concentrating on 3 economic blocs (BRCIS, MINTS and ECOWAS), Muye and Muye (2017) investigated the relationship between financial development, institutional quality and globalization. Their empirical result indicates that globalization promotes financial and quality institution boosts globalization-financial development nexus. The outcome of the study of Balcilar *et al.* (2019) indicates that economic globalization stimulates by improving the effectiveness of financial institutions in 36 developed and developing countries. In investigating the association between environmental degradation, globalization, financial development, economic growth and energy consumption in India over the period of 1980 and 2015, Sethi, Chakrabarti and Bhattacharjee (2020) employed ARDL technique and finds that globalization, economic growth increased energy consumption and degrades the environment. Likewise, Shahbaz, *et al.* (2020) employs Bootstrapping ARDL methodology to examine the link among economic growth, R&D expenditures, financial development, and energy consumption and carbon dioxide emissions in UK. According to their empirical finding, energy consumption and financial development degrades the environment while R&D expenditures reduce CO₂ emissions. By incorporating corruption into finance-growth linkage in 142 countries spanning 2002 and 2016, Song, Chang and Gong (2020) established that economic growth strengthens financial development in both developed and developing countries while corruption worsen financial development in developing countries.

In sum, the above literature suggests a diverse finding on the nexus between financial development and growth and its determinants across countries. To the best of our knowledge, no research work has been carried out on African countries using comprehensive globalization and financial development index, making it a motivation.

3. Research Method

For this study, we analyze annual data from 1990 to 2018 for 25 African economies to probe the finance-growth nexus in the presence of globalization. The justification for the selected countries and time frame is based on availability of data. In order to simplify coefficient interpretations and overcome the problem of heteroscedasticity, all the dataset is transformed to natural logarithm (Faisal, Sulaiman and Tursoy, 2019). The data employed in this study are economic growth (proxied by GDP per capita measured at constant A2010 US Dollars), Following Dreher (2006) and Gygli *et al.* (2019), globalization is measure as economic, social and political globalization. In line with Sahay *et al.* (2015) and Nasreen *et al.*, (2020), financial development is measured by financial access (proxied by commercial bank branches per 100,000 adults and ATMS per 100,000 adults), financial depth (proxied by private-sector credit to GDP, stock market capitalization to GDP, stock traded to GDP and liquid liability to GDP) and efficiency (proxied by stock market turnover ratio). Data on economic growth is sourced from World Bank Indicator 2020 edition while data on globalization is collected from the globalization KOF index by Dreher (2006) and Gygli *et al.* (2019). Lastly, data on financial development is collected from World Bank Global Financial Development Database (GFDD). The selected countries for this study are: Angola, Algeria, Benin, Botswana, Cameroon, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Kenya, Morocco, Mali, Mauritania, Mauritius, Namibia, Nigeria, Senegal, Seychelles, Tunisia and South Africa.

3.1 Econometric Strategy

Building on the previous empirical studies, the inter linkage amongst finance, globalization and growth is specified as:

$$Y = f(FIN, GLOB) \quad [1]$$

Where economic growth is represented by Y , FIN denotes financial development and $GLOB$ is globalization. Expressing equation (1) in econometric form becomes:

$$Y_{it} = \sigma + \pi FIN_{it} + \eta GLOB_{it} + \beta Z_{it} + \mu_{it} \quad [2]$$

where Y denote economic growth, σ denotes country – specific intercept, FIN is financial development and $GLOB$ is globalization while i denotes the country, t is the time period, error term is symbolized by μ_{it} and Z_{it} denote the control variable (macroeconomic uncertainty (proxied by CPI-based inflation) and domestic investment (proxied by gross capital formation as a ratio of GDP)) because they have been empirically proven to have vital impact on economic growth (Osei and Kim (2020)).

To probe the presence of globalization in finance-growth nexus, the technique of panel autoregressive distributive lag model (PARDL) developed by Pesaran *et al.* (1999) is utilized. This estimation technique has several merits over static models because it accounts for heterogeneity in a dynamic panel setting (Rafindadi, Muye & Kaita, 2018; Samargandi, et al. 2015). Further, this method accommodate variables of different integration order; I (0) and/or I(1) (Rafindadi, Muye & Kaita, 2018); and also, it generates reliable estimates in the presence of endogeneity (Chen & Vujic, 2016; Chudik et al., 2013; Pesaran et al., 1999; Pesaran & Smith, 1995). Lastly, the short-run and long-run models are estimated simultaneously (Pesaran et al., 1999). Thus, this technique gets rid of problem of slope heterogeneity across

countries, order of integration in variables and cross-sectional dependence (Rafindadi, Muye & Kaita, 2018; Chen & Vujic, 2016).

The technique has 3 estimators namely, the mean group (MG), pooled mean group and dynamic fixed effect. The MG estimator assumes heterogeneity in all coefficients and uses the average of the long-run coefficients of each cross-section to estimate the long-run parameters. However, the dynamic fixed effect (DFE) estimator assumes homogeneity in all coefficients and incorporated the lagged term of the dependent variable as one of the independent variables. Lastly, for the pooled mean group (PMG) estimator, only the long-run slope coefficients are homogeneous while the short run parameters are heterogeneous. The appropriateness of these estimators is decided using the Hausman test.

The general form of panel autoregressive distributed lag (ARDL) (p, q) is model as follows:

$$Y_{i,t} = \sigma_i + \sum_{k=1}^p \pi_{ik} Y_{i,t-k} + \sum_{k=0}^q \phi'_{ik} X_{i,t-k} + \mu_{it} \quad [3]$$

$$\text{Where } X_{i,t} = (FIN_{i,t}, GLOB_{i,t}, Control_{i,t}), \text{ and } Control_{i,t} = (INF_{i,t}, INV_{i,t}) \quad [4]$$

Where t symbolize time element (annual), country index is represented by i and σ_i denotes country fixed effects. In addition, k time lags. In equation (4), the dependent variable is denoted by Y_{it} ; the vector X_{it} represents financial development, globalization and control variables (investment and macroeconomic uncertainty). Equation (3) can be re-parameterized into:

$$\Delta Y_{i,t} = \sigma_i + \phi_i Y_{i,t-k} + \mathcal{G}'_i X_{i,t} + \sum_{k=1}^p \pi_{ik} Y_{i,t-k} + \sum_{k=0}^q \theta'_{ik} X_{i,t-k} + \mu_{it} \quad [5]$$

Where

$$\phi_i = -1 \left(1 - \sum_{k=1}^p \gamma_{ik} \right) \quad [6]$$

$$\mathcal{G}_i = \frac{\sum_{k=0}^q \theta_{ik}}{\left(1 - \sum_{k=1}^p \gamma_{ik} \right)}, \quad \gamma_{ik}^* = - \sum_{n=k+1}^p \gamma_{in} \text{ and } \theta_{ik}^* = - \sum_{n=k+1}^q \theta_{in} \quad [7]$$

Equation [3.7] in Error correction form is specified as:

$$\Delta Y_{i,t} = \sigma_i + \phi_i (Y_{i,t-j} - \mathcal{G}'_i X_{i,t}) + \sum_{k=1}^p \pi_{ik} Y_{i,t-k} + \sum_{k=0}^q \theta'_{ik} X_{i,t-k} + \mu_{it} \quad [8]$$

$$\phi_i < 0$$

Where $\phi_i (Y_{i,t-j} - \mathcal{G}'_i X_{i,t})$ is the adjustment in Y_{it} to the deviation from its long-run relationship and short-run coefficients linking Y_{it} with its lag values and other independent variables are γ_{ij}^* and θ_{ij}^* . In addition, ϕ_i is the error-correction coefficient estimates which

measures the speed of adjustment of Y_{it} toward its long-run equilibrium in case of a change in any of the independent variables X_{it} . In order to ensure that long run relationship exist among the variables, the speed of adjustment ϕ_i must be negative and significant.

4. Result and Discussion

This section focuses on result presentation. The descriptive statistics and correlation matrix gives first-hand descriptions of the relevant data employed in this study. Table 1 presents the result of the descriptive statistic and correlation matrix of 21 African economies spanning 1990 and 2017. From Table 1, the average income per capita is \$3282.20 and ranges between \$14014.87 and \$164.33. The mean values of financial and globalisation index are 0.1957 and 50.1258 while the average of investment and macroeconomic uncertainty are 21.17 and 25.47 respectively. Volatility in economic growth is higher than volatility stems in financial development and globalization index. The correlation matrix shows a positive association between growth and urbanization, which is not surprising for a heavily income per capita and financial development and globalization index. Similarly, we observe that growth and inflation are negatively related.

Table 1: Summary Statistics and Correlation

Variable	N	Mean	Std. Dev	Min	Max
Y	588	3282.20	3016.683	164.3366	14014.87
FIN	588	0.1957	0.1106	0.0645	0.6266
GLOB	588	50.1258	9.8571	22.356	72.354
INV	588	21.1779	10.2619	1.9833	61.4690
INF	588	25.4795	215.1075	-11.6861	4145.106
Y	1.000				
FIN	0.4627	1.0000			
GLOB	0.4038	0.6721	1.0000		
INV	0.1322	-0.0002	0.0802	1.0000	
INF	-0.0418	-0.0600	-0.1089	-0.1547	1.0000

Note: Y, FIN, GLOB, INV, INF denote income per capita, financial development, globalization, investment (proxied by gross capital formation) and macroeconomic uncertainty (proxied by consumer price index) respectively.

In order to know the order of integration of the variables employed for this study, first generation panel unit root tests such as Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS) and Breitung panel unit root tests are utilized. The empirical result of the panel unit root test is presented in Table 2. We observed that gross domestic product per capita (LY), globalization index (LGLOB) and investment (LINV) contain unit root while financial development index and macroeconomic uncertainty are found to be stationary at level. After the first difference, all the variables are stationary. This shows that the variables have a mixed order of integration. According to Pesaran et al. 1995, 1999, panel ARDL is applicable if variables contain a mixed order of integration, based on this, we proceed to evaluate the nexus between financial development and economic growth in the presence of globalization.

Table 2: Panel Unit Root Test

Variables	LLC Test		IPS Test		BREITUNG Test	
	Level	First Diff	Level	First Diff	Level	First Diff
IY	-1.6772	-14.3492***	0.0752	-13.1171***	1.4020	-6.5667***
FIN	-5.0807**	-20.9488***	-3.3693**	-15.6927***	3.1917**	-14.6132***
IGLOB	-2.3631	-18.7724***	-1.6871	-13.5437***	6.2188	-19.8292***
IINV	-7.1196	-19.3023***	-1.6878	-14.6279***	-0.7454	-12.6797***
IINF	-10.0543**	-23.5173***	-2.5786**	-14.017***	-5.5175**	-9.6037***

Note: Y, FIN, GLOB, INV, INF denote income per capita, financial development, globalization, investment (proxied by gross capital formation) and macroeconomic uncertainty (proxied by consumer price index) respectively. Note 2: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. The null hypotheses of Levin, Lin and Chu, Im, Pesaran and Shin (IPS) and Breitung tests are that the underlying series are nonstationary.

In this study, cross dependence test developed by Pesaran (2004) is applied to check for cross-sectional dependence among the variables. The CD test is utilized because African countries tend to exhibit similar traits and are interconnected via trade, globalization due economic union and other networks. The result of the Pesaran CD (2004) cross dependency test is displayed in the first column of Table 3 and the result indicates that all variables considered in this study have cross-sectional bias problem. Since the performance of traditional unit root tests such as LLC, IPS, Breitung tests can be influence by the presence of cross dependence (Nathaniel et al. 2020; and Ahmed and Le, 2020). Thus, in order to overcome this problem, we employed Cross-Sectional Augmented Panel Unit Root (CIPS) and Cross-Sectional Augmented Dickey-Fuller (CADF) panel Unit root test of Pesaran (2007) which gives reliable and consistent result. The result of the CIPS and CADF panel unit root presented in Table 4 suggests that all the variables are stationary at level except economic growth (LY). After first difference, economic growth becomes stationary.

Table 3: Cross Dependency Test and Panel Unit Root Test

Variables	CD Test		CIPS Test		CADF Test	
	CD	Obs(corr)	Level	First Diff	Level	First Diff
IY	50.61***	0.828	-1.807	-4.225***	-1.810	-3.194***
FIN	43.66***	0.587	-2.645**	-5.344***	-2.467**	-4.342***
IGLOB	70.05***	0.914	-2.687**	-5.066***	-2.719**	-4.035***
IINV	4.92**	0.400	-2.485**	-4.986***	-2.434**	-3.729***
IINF	13.43**	0.273	-3.284***	-5.823***	-2.344**	-4.863***

Note: Y, FIN, GLOB, INV, INF denote income per capita, financial development, globalization, investment (proxied by gross capital formation) and macroeconomic uncertainty (proxied by consumer price index) respectively. Note 2: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively. The null hypothesis of CD test states that there exist no CD among sample countries while the alternative hypothesis states there exist CD among sample countries. The null hypothesis for the CIPS and CADF unit root tests assumes homogeneous non-stationary as against the alternative hypothesis of possible heterogeneous alternatives.

Table 4 report the result of the panel ARDL (pooled mean group, mean group and dynamic fixed effect) on the nexus between financial development, globalization and economic growth among 21 African economies spanning 1990 and 2017. Hausman test is applied to select the best estimator among PMG, MG and DFE. The result of the Hausman test support the PMG

estimator as the efficient estimator, then the use of a MG or DFE estimator is unsuitable. Thus, the interpretation of this study will be based on PMG estimator. The result of the PMG estimator indicates that financial development exerts a positive and significant impact on economic growth in both short and long run, that is, a 1% increase in financial development foster African economies by 2.451 and 0.302 percent in both long run and short run respectively. This finding validates the result of Botev and Jawadi (2019) that finance stimulate economic growth in developed countries but refutes the result of Muazu and Ibrahim (2018) and Redmond and Nasir (2020) whose study finds that financial development hinders SSA growth. The result supports the supply-leading hypothesis that a well-developed financial sector lessens transaction costs and augment economic growth. Furthermore, globalization has a positive and significant influence on economic growth in the long run though insignificant in the short run. The results indicates that globalization foster growth by 0.986% and 0.0975% in the long and short-term respectively. This outcome supports the study of Brueckner and Lederman (2015). This finding suggests that African economies attract more external financing and improves production processes which paves the way for economic development. The coefficient of physical capital investment is positive and significant in both short and long run, thus confirming the important role played by physical capital in African's growth. However, the coefficient of macroeconomic uncertainty (proxied by consumer price index) is negative and significant in the long run but insignificant in the short run. This implies that macroeconomic uncertainty impedes African economies. Lastly, a significant negative coefficient of the error correction is necessary to substantiate a statistically significant relationship over the long run. The results of empirical testing affirm a short- and long-run relationship between financial development, globalization and economic growth among African countries.

in OPEC countries. Table 4 suggests that error correction coefficient (ECM) is -0.0985, which is significant at the 1% level, implying that a 9.85% adjustment takes place after temporal shocks in the long-run equilibrium relationships between economic growth, financial development and globalization.

Table 4: Panel ARDL Regression result

Dep. Variable: LY			
VARIABLES	PMG	MG	DFE
Long-run Estimate			
<i>LFIN</i>	2.451*** (0.329)	3.664 (2.610)	0.773 (0.655)
<i>LGLOB</i>	0.986*** (0.0826)	0.748* (0.402)	1.618*** (0.249)
<i>LINV</i>	0.129*** (0.0198)	0.162 (0.106)	0.0993*** (0.0353)
<i>LINF</i>	-0.0286*** (0.00881)	-0.0590** (0.0239)	-0.0409 (0.0254)
Short run Estimate			
<i>ECT(-1)</i>	-0.0985*** (0.0223)	-0.205*** (0.0325)	-0.0729*** (0.0124)
ΔFIN	0.302**	0.307*	0.233**

	(0.139)	(0.171)	(0.0942)
$\Delta LGLOB$	0.0975	0.126**	0.0435
	(0.0653)	(0.0534)	(0.0475)
$\Delta LINV$	0.00224	-0.00103	0.00926**
	(0.0181)	(0.0166)	(0.00434)
$\Delta LINF$	-0.000466	-0.00370**	-0.00424**
	(0.00196)	(0.00182)	(0.00174)
Constant	0.295***	0.981***	0.0876
	(0.0708)	(0.286)	(0.0745)
Observations	567	567	567
Hausman	MG vs PMG		PMG vs DFE
Chi2(4)	1.30		1.01
Prob	0.8613		0.6821

Note 1: Y, FIN, GLOB, INV and INF represents income per capita, financial development, globalization, investment (proxied by gross capital formation) and macroeconomic uncertainty (proxied by consumer price index). Note 2: ***, **, * indicate statistical significance at 1%, 5% and 10% respectively while values in () are standard errors. Hausman test is indicating that PMG is consistent and efficient estimation than MG and DFE estimation.

5. Conclusion.

This study aims to investigate the link between growth, financial development and globalization using a multivariate framework on panel data sets of 21 African countries from 1990 to 2017. The findings of this study are vital for understanding the relationship among financial development, globalization and economic growth in African countries. Particularly, our findings suggest that financial development and globalization plays a significant role in promoting economic growth of African countries. Further, results indicate that physical capital investment has an important role in accelerating economic performance of African economies. Based on these findings, it is important for African countries to promote globalization-financial development policies in order to have access to alternative sources of external financing and attract foreign investment that can spur growth of African countries.

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Renewable Energy Consumption and Sectoral Based Output

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Abstract

The study explores the effect of renewable energy consumption on sectoral output in the presence of government effectiveness. A regressions method was used to analyze data from 1989 to 2019. The result revealed evidence of the positive and vital impact of renewable energy consumption on the sectoral output of the manufacturing and construction sectors. Although the elasticity of government effectiveness is neutral, trade openness has revealed evidence of positive and significant impact on sectoral outputs. However, population growth does not have a favourable impact on sectoral outputs. Furthermore, renewable energy consumption is not essential in determining the agricultural sector, transportation sector and other sectors. To quickly diversify the economy, policymakers should further increase awareness and provide more incentives for renewable energy in these sectors.

Key words: Renewable Energy; Sectoral Output; Effectiveness of Government.

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1. Introduction

The need for sustainable economic growth and development has spurred the interest to increase the share of renewables in the total energy mix in economic activities in the African countries (UNFCCC, 2018). This is due to the vast potentials of renewable energy sources in the African sub-region. More importantly, renewable energy is a cleaner source of energy compared to other energy sources. However, access to a clean energy source for sustainable growth and development has remained a challenge to Nigeria and other African countries.

The following reasons inspire this study: The need to exploit the abundant renewable energy sources in Nigeria (solar, wind, hydropower, biomass); the fact that renewable energy can quickly be replenished within a relatively short period; the urge for sustainable economic growth process that does not compromise resource of the future generation; the paucity of studies on the nexus between renewable energy consumption and sectoral output in Nigeria such as, output

from the manufacturing sector, construction sector, agricultural sector, transportation sector, mining sector, wholesale and retail trade sector are yet to be examined.

First, despite that Nigeria is presently generating renewable energy from hydropower, solar, wind and biomass, there exists enormous potential of renewable energy that is yet to be harnessed. Renewable energy only accounts for about 18% of total energy utilization in Nigeria (ECN, 2018). This less usage of renewable energy has contributed to the current slow pace of gross domestic product growth rate at about 1.9% since 2018. Second, unlike fossil fuel energy sources like petroleum, natural gas, and coal, renewable energy in Nigeria is not finite; it cannot quickly be exhausted.

Third, the use of renewable energy to achieve economic growth is sustainable, but fossil fuel energy depletes future generations' energy resources are not sustainable (EIA, 2017). About 80% energy source used for the economic growth process in Nigeria comes from non-alternative energy sources. Hence, there is a need for an urgent shift to renewable energies. Fourth, although recent studies have emerged on renewable energy and economic growth nexus in Nigeria (Oyedepo, 2012; Maji, 2015; Rafindadi, 2016; ENC, 2018; NBS, 2019), there is a scarcity of studies that examines the relationship between renewable energy and sectoral based output in Nigeria.

This study aims to investigate the impact of renewable energy on sectoral output in Nigeria in the presence of government effectiveness. The study considers sectoral output indicators from the manufacturing sector, construction sector, agricultural sector, transportation sector, and other sectors to contribute to knowledge. Considering sectoral based output measurements enable the study to provide a sectoral based policy implication.

2. Literature review

The link between renewable energy and economic growth has recently occupied an important stage in the literature. Empirical studies relating to this nexus seems to be divided into three groups. One group of the study investigates the effect of renewable energy on economic growth (Chang et al., 2015). Another group of the study examines the impact of renewable energy and non-renewable energy on economic growth (Dogan, 2015). While the third group of the study considers a causal link between renewable energy and economic growth by emphasizing the four main hypotheses (Maji et al., 2019). However, investigating the relationship between renewable energy and sectoral output seems to have eluded literature.

The first group of literature that examines the relationship between renewable energy and economic growth have used a time series analysis (see Lin and Moubarak, 2014; Maji, 2015; Rafindadi and Ozturk, 2016). A similar relationship has also been investigated using a panel data analysis (Alper and Oguz 2016; Kahia et al., 2016; Bhattacharya et al., 2016; Amri, 2017; For instance, Maji (2015) employed a time series analysis for a study in Nigeria, while Alper and Oguz (2016) and Bhattacharya et al. (2016) used a panel analysis and found a positive and significant impact of renewable energy on the economic growth of their respective countries. On the other hand, Chang et al. (2015) and Amri (2017) found a bidirectional relationship between renewable energy and economic growth.

Recent studies which do not include sectoral analysis of output in their investigation have also emerged (Bamati and Raoofi, 2019; Topcu and Tunsel, 2019; Bellakhal et al. 2019; Lee and Mccuskey, 2020). Renewable energy investment was assumed to be hindered by key governance factors (Bellakhal et al., 2019). After conducting an empirical investigation, the result reveals that higher institutional quality is essential to renewable energy investment of the countries. Furthermore, Topcu and Tugcu (2019) maintained that renewable energy consumption reduces income inequality; education level, age, gender and households' income are essential determinants of readiness to pay for renewable energy (Dogan and Muhammad, 2019). While renewable energy generation is an essential determinant of technology export in developed countries and not in developing countries (Bamati and Raoofi, 2019).

The second group of the literature has hinted at the impact of renewable energy and non-renewable energy on economic growth (see Dogan, 2015; Kahia et al., 2016; Narayan and Doytch, 2017). In the presence of structural break, Dogan (2015) examines the relationship between renewable, non-renewable energy consumption and economic growth. While renewable energy consumption has an insignificant impact on economic growth, non-renewable energy consumption positively and significantly impacts economic growth. Similarly, Kahia et al. (2016) recently revealed evidence from Net Oil Exporting Countries (NOEC) that bidirectional causality exists between renewable energy and economic growth. The result further shows that substitutability exists between non-renewable and renewable energy types.

The third group of studies (Kahia et al., 2016; Rafindadi, 2016; Adewuyi and Awodumi, 2017; Maji et al., 2019) have paid attention to the four main hypotheses nexus between renewable energy and economic growth. These are the growth hypothesis, the conservation hypothesis, the unidirectional hypothesis and the neutral hypothesis (Kahia et al., 2016). The growth hypothesis maintains that renewable energy is among the energy source that facilitates economic growth. The conservation hypothesis posits that the urge for sustainable economic growth leads to the demand for renewable energy. The unidirectional hypothesis suggests that economic growth can cause renewable energy consumption, which can cause sustainable economic growth. On the other hand, the neutral hypothesis postulates that neither economic growth nor renewable energy causes each other (Maji et al., 2019).

Furthermore, this study contributes to the literature by using variables such as renewable energy consumption, government effectiveness, economic growth, trade openness, population and sectoral outputs. The selection of these variables has helped in differentiating this study from other existing studies. For instance, Dogan (2015), Kahia et al. (2016), Rafindadi and Ozturk (2016) and Narayan and Doytch (2016) all used the variables of economic growth, renewable energy consumption but do not consider institutional quality, trade openness, population and sectoral output variables. Similarly, Bhattacharya et al. (2016) used institutional quality but did not consider trade openness, population growth and sectoral outputs. However, trade openness is essential to capture globalization; the population is needed to capture the market and sectoral output to identify sectors that drive an economy. Therefore, analyzing renewable energy and sectoral output is scarce in the literature, thus establishing a research gap. This study intentions to address this gap by focusing on output from the manufacturing sector, construction sector, agricultural sector, transportation sector and other sectors.

3. Methodology

3.1. Model and analytical tool

The modelling framework of this study is the conservation theory of energy and economic growth nexus. The theory posits that economic growth is the key driver of energy consumption. As a result, the causal link runs from economic growth to energy consumption. However, to achieve sustainable economic growth, which does not compromise the resource of the future generation, the use of cleaner energy is required. Clean energy is that component of energy that can quickly be regenerated within a relatively short period without any adverse effect on humans and the environment.

The analytical tool for this study is the Ordinary Least Squares (OLS) regression analysis. The basis of employing the OLS is that it chooses the coefficients of a linear regression of a given independent variable using the principles of least squares that minimized the sum of squares of differences between a dependent variable and the explained variable of a regression function (Ibrahim and Chanchaoenchai, 2015). This minimizes estimation errors and helps to avoid spurious results. Thus, resting on this analytical tool, sectoral outputs are specified as a function of renewable energy and other conditional variables. These variables include renewable energy consumption, government effectiveness, trade openness and population growth. The specification is presented in equation (1).

$$so_{ti} = f(rec_t, gef_t, gdpc_t, tro_t, pog_t) \quad (1)$$

The logarithm of equation (1) was taken before converting it into an econometric form by including intercept and error. so represents sectoral output indicators, where the subscript i denote the output of the manufacturing sector, construction sector, agricultural sector, transportation sector and other sectors. The error term needs to be normally distributed with zero mean and constant variance to be white noise.

$$lnso_{ti} = f(lnrec_t, lngef_t, lngdpc_t, lntro_t, lnpg_t) \quad (2)$$

$$lnso_{ti} = \varphi_0 + \varphi_1 lnrec_t + \varphi_2 lngef_t + \varphi_3 lngdpc_t + \varphi_4 lntro_t + \varphi_5 lnpg_t + \vartheta_t \quad (3)$$

Where $lnso_{ti}$ denotes output from the manufacturing sector ($lnoms_t$), the output of the construction sector ($lnocs_t$), the output of the agricultural sector ($lnoas_t$), the output of the transportation sector ($lnots_t$) and other sectors ($lnoos_t$). $lnrec_t$ stands for renewable energy consumption, $lngef_t$ represents government effectiveness, $lngdpc_t$ represent output per capita, $lntro_t$ denotes trade openness, $lnpg_t$ is population growth. φ_0 is the intercept, $\varphi_1 - \varphi_5$ are the coefficients of the explanatory variables, and ϑ_t is the error term.

We expect $\varphi_1 - \varphi_5 > 0$, however, if renewable energy, government effectiveness, trade is not efficient then $\varphi_1 - \varphi_4 < 0$. Similarly, if the population growth is not sustainable then $\varphi_5 < 0$. Thus, the study initially hypothesized that renewable energy consumption, government effectiveness, trade openness and population will have a positive effect on sectoral output

3.2. Data sources

The dataset for this work is sourced from World Development Indicators (WDI), Word Governance Indicators (WGI) and United Nations Statistical Division (UNSD) from 1989 to 2019. The variables of sectoral output are measured as output from the manufacturing sector, output from the construction sector, output from the agricultural sector, output from the transportation sector and output from other sectors. The measurement for renewable energy is renewable energy consumption (% of total final energy consumption); the measurement for government effectiveness is government effectiveness percentile rank; per capita output is measured as GDP per capita (constant 2010 US\$), trade openness is measured by trade (% GDP) while population growth is measured as population growth % of the total. The availability of data limits this study. Therefore, the sectoral output considered in this study is the one in which data are available. The trend of variables is presented in Figure 1. Most variables in the figure have shown a moderate upward movement from inception up to 2019.

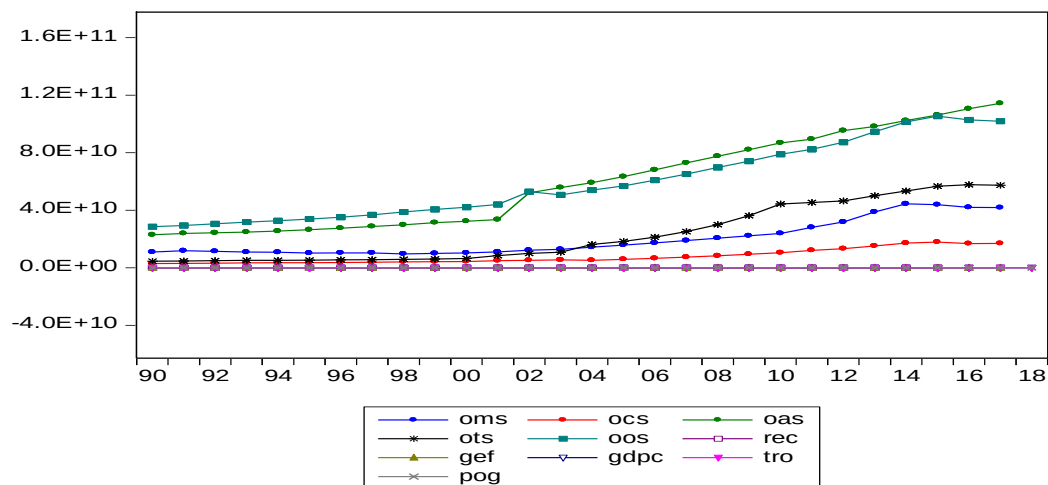


Figure 1. Trend of variables

4. Result and discussion

The result discussion begins with the presentation of the unit root test. The unit root test is a stationarity test that verifies the level of integration of the variables. If variables are stationary, it means that they are time-invariant. To avoid spurious results, a stationary test is necessary before conducting a regressions analysis. The unit root test was conducted on the variables using the Augmented Dickey and Fuller (1981) and Phillips and Perron (1988), and the result is presented in Table 1. The result suggests that all the variables are stationary, as indicated by the statistical level of significance in the footnote of Table 1.

Table 1: Results of unit root test for renewable energy consumption and sectoral outputs

Variables	ADF		PP	
	Level (0)	First difference (1)	Level (0)	First difference (1)
$lnoms_t$	-0.487 (0.879)	0.348 (0.975)	0.923 (0.994)	-1.998** (0.045)
$lnocs_t$	0.056 (0.956)	-2.525 (0.120)	1.139 (0.996)	-1.837* (0.063)
$lnoas_t$	1.474 (0.998)	-4.436*** (0.001)	1.444 (0.998)	-4.426*** (0.001)
$lnots_t$	0.073 (0.957)	-2.536 (0.118)	1.142 (0.996)	-1.673* (0.088)
$lnoos_t$	0.732 (0.990)	-3.970*** (0.005)	0.653 (0.988)	-3.980*** (0.005)
$lnrec_t$	-2.653* (0.096)	-5.133*** (0.000)	-2.653* (0.096)	-5.281*** (0.000)
$lngef_t$	-4.360*** (0.001)	8.875*** (0.000)	-4.304*** (0.002)	-8.875*** (0.000)
$lngdc_t$	-0.348 (0.905)	-2.928** (0.055)	0.370 (0.902)	-2.953** (0.052)
$lnro_t$	-3.032** (0.044)	-4.995*** (0.000)	-3.032** (0.044)	-8.610*** (0.000)
$lnpog_t$	-3.007** (0.047)	-1.562 (0.486)	-1.302 (0.614)	-1.732 (0.404)

Note: Values in parentheses (.) are *p*-values, ***, ** and * indicate significance at 1%, 5% and 10% respectively.

After the unit root test, a descriptive statistic of the variables was presented in Appendix A. The Johansen cointegration test was further carried out to ascertain the long-run and equilibrium relationship between renewable energy and sectoral outputs. As presented in the lower part of Table 2, the result indicates that all the sectoral output models are cointegrated; as such, we can proceed with regression analysis. The regression analysis of the impacts of renewable energy consumption on sectoral output is also presented in the upper part of Table 2. The sectoral output results are presented in the following format. The presentation begins with output from the manufacturing sector ($lnoms_t$), output from the construction sector ($lnocs_t$), output from the agricultural sector ($lnoas_t$), output from the transportation sector ($lnots_t$) and output from other sectors ($lnocs_t$) (see Maji and Adamu (2021) for renewable energy consumption and sectoral analysis).

Model 1 presents the impact of renewable energy consumption on sectoral output from the manufacturing sector. The finding reveals that renewable energy consumption has a positive and significant impact on the manufacturing sector's output. This suggests that an increase in renewable energy usage in the economic activities of the manufacturing sector will increase the output of the sector. This finding implies that despite that the manufacturing sector of the

Nigerian economy is yet to be developed, the use of renewable energy will sustainably increase the sector's output towards achieving economic diversification. This finding is consistent with the work of Narayan and Doytch (2016). The result of government effectiveness is not significant, but population growth harms the manufacturing sector's output.

Table 2. Impact of renewable energy consumption and sectoral output

Sectoral outputs		Regression models					Constant
		$lnrec_t$	$lngef_t$	$lngdc_t$	$lntr_o_t$	$lnpog_t$	
$lnoms_t$	1	3.384** (1.398)	-0.062 (0.108)	2.789*** (0.186)	-0.125 (0.956)	-6.148*** (1.672)	-5.979 (6.407)
$lnocs_t$	2	4.155** (1.804)	-0.218 (0.139)	3.722*** (0.239)	0.225* (0.123)	-11.803*** (2.158)	-12.879 (8.269)
$lnoas_t$	3	-1.301 (1.996)	-0.052 (0.154)	3.138*** (0.265)	0.251* (0.136)	-6.749*** (2.387)	12.568 (9.147)
$lnots_t$	4	2.935 (2.379)	-0.118 (0.184)	4.981*** (0.316)	0.374** (0.163)	-8.104*** (2.847)	-20.332* (10.908)
$lnoos_t$	5	1.366 (1.445)	-0.153 (0.112)	2.829*** (0.192)	0.251** (0.098)	-9.633*** (1.729)	6.043 (6.624)
		Diagnostic tests				JC_test (Trace)	
		Nor	$serl$	Het	fun	$r \leq 1$	$r \leq 2$
$lnoms_t$	1	0.038 [0.981]	2.063 [0.124]	2.884 [0.103]	18.809 [0.100]	114.077***	69.457***
$lnocs_t$	2	0.137 [0.933]	3.106 [0.038]	0.577 [0.454]	3.781 [0.019]	92.093***	47.918**
$lnoas_t$	3	1.765 [0.413]	6.707 [0.102]	1.048 [0.417]	7.992 [0.001]	121.522***	64.651***
$lnots_t$	4	0.814 [0.665]	0.847 [0.445]	1.734 [0.13]	3.525 [0.126]	138.608***	67.463***
$lnoos_t$	5	1.623 [0.444]	3.873 [0.022]	1.288 [0.307]	0.895 [0.524]	108.422***	52.069**

Note: Values in parentheses (.) and [.] are standard errors and p values respectively. ***, ** and * represent significance at 1%, 5% and 10% respectively. $Norm$, $serl$, Het , and fun are diagnostic tests for normality, serial correlation, heteroskedasticity, and functional specification while JC_test stands for Johanssen cointegration test.

The impact of renewable energy consumption on the sectoral output of the construction sector is presented in Model 2 of Table 2. The result shows that renewable energy consumption has a positive and important impact on the construction sector's output, suggesting that higher renewable energy consumption facilitates more output from the sector. This implies that more renewable energy needs to be harnessed to increase output from the construction sector as a share of the total gross domestic product. Increasing the output of this sector will reduce over-

reliance on crude oil and thus, provide the additional option of diversifying the economy to policymakers. This outcome corroborates the earlier empirical literature (Alper and Oguz, 2016; Narayan and Doytch, 2016). Moreover, the result of government effectiveness is not significant; trade openness reveals a positive impact on output from this sector while population growth adversely affects the construction sector's performance.

Furthermore, the result of models 3-5 shows that the relationship between renewable energy consumption and sectoral output from the agricultural sector, transportation sector and other sectors is not significant, indicating that the coefficient of renewable energy of these sectors does not have the statistical power to impact on output from these sectors. The finding implies low usage of renewable energy in economic activities in the agricultural, transportation and other sectors in Nigeria. Perhaps, the cost of renewable energy usage in these sectors at the moment may be too higher compared to the marginal benefit as such inefficient. Similarly, trade openness facilitates output of the agriculture, transportation and other sectors. However, population growth reveals evidence of reducing output from these sectors. This finding supports an earlier study (Dogan, 2015).

The diagnostic test results of Model 1-5 for normality, serial correlation, heteroskedasticity and functional specification are presented in the lower part of Table 2. The results passed most of the tests as suggested by the probability values in parentheses.

5. Conclusion

The study explores the relationship between renewable energy consumption and sectoral outputs in the presence of institutional quality in Nigeria. A regressions method was employed to analyze a sample of data for the period of 1989 – 2019. The result revealed evidence that renewable energy consumption has a positive and significant impact on the sectoral output of the manufacturing and construction sectors. However, renewable energy consumption is not important in determining the output of the agricultural, transportation and other sectors. Furthermore, the elasticity of government effectiveness is not significant, implying that government is less effective in the public and civil service and not independent from political pressure. Equally, trade openness has consistently revealed a positive and important impact on sectoral outputs. However, population growth does not have a favourable impact on all the sectoral outputs under consideration.

The implications of these findings are as follows. First, renewable energy importantly promotes economic activities in the manufacturing and construction sectors. Thus, policymakers should pay attention to renewable energy in these sectors as the main drivers of economic diversification in Nigeria. Second, the impact of renewable energy consumption is neutral in the agricultural sector, transportation sector and other sectors. This implies lower usage of renewable energy in these sectors; as such, policymakers should create awareness and provide more incentives to encourage the use of renewable energies in these sectors to achieve the government's objective of diversifying the economy. Third, the effect of government effectiveness is also neutral. This suggests the need to improve government presence in civil and public services and its independence from political pressures. Fourth, since trade openness positively affects sectoral outputs, policymakers should further leverage the comparative trade advantages from these

sectors. Finally, further studies should consider other sectors and another measurement of renewable energy for new policy implications.

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Appendix

Appendix A: Descriptive statistics

variables	<i>rec</i>	<i>gef</i>	<i>gdp</i>	<i>tro</i>	<i>pop</i>	<i>oms</i>	<i>ocs</i>	<i>oas</i>	<i>ots</i>	<i>oos</i>
Mean	4.455	2.661	7.524	3.669	0.950	23.981	22.700	24.751	23.571	24.954
Median	4.458	2.729	7.543	3.692	0.954	23.865	22.550	24.867	23.6427	24.922
Maximum	4.486	3.048	7.849	3.975	0.986	24.580	23.616	25.348	24.867	25.559
Minimum	4.418	2.153	7.208	3.065	0.911	23.748	22.008	23.998	22.057	24.411
Std. Dev.	0.016	0.216	0.235	0.221	0.029	0.266	0.527	0.480	1.018	0.378
Skewness	-0.566	-0.650	-0.074	-0.862	-0.119	1.344	0.412	-0.417	-0.167	0.134
Kurtosis	2.837	2.951	1.532	3.790	1.317	3.394	1.817	1.654	1.529	1.667
Jarque-Bera	1.090	1.414	1.812	3.002	2.407	6.150	1.7308	2.090	1.895	1.540
Probability	0.579	0.493	0.404	0.222	0.300	0.046	0.420	0.351	0.387	0.462
Observations	20	20	20	20	20	20	20	20	20	20

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Challenges on Taxi Management in Kathmandu Valley: Taxi Drivers Perspectives

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Abstract

Taxi as a means of transportation has been emerging as a handy option for people of any age for any occasion if they need to travel. Thus, this study aims to analyze challenges on taxi management in Kathmandu valley, Nepal, from the perspective of taxi drivers. A descriptive method is applied in the survey, and qualitative analysis is made among 386 taxi drivers of Kathmandu valley. The study's findings revealed that 77% of taxi drivers face challenges in the valley. Significant challenges arise from increasing private vehicles and easy access to public transportation, emergence of online vehicle service providers, government rules and regulations, and parking difficulties. Therefore, the study concludes that policymakers and responsible authorities should consider the strategy to improve the overall taxi management system in the valley. This study can be useful to concerned authorities in taxi management services to make strategies for the betterment and to mitigate the challenges in the field. If the taxi management system got effective, that would be encouragement for other vehicle management.

Key Words: Taxi service, Digital service, Taxi drivers, Taxi management

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1. Introduction

In big cities and towns, people's mobility is constantly increasing, but the resources are limited, demanding to maximize the use of resources (Król & Król, 2019). Transportation is any medium through which we can reach from place to place. Mass public transport has been the subject for many years. Still, its drawbacks, such as inflexibility, long total travel time, overcrowding and inadequate service coverage, mean that the taxi industry continues to play a significant role (Oliver, 2013). Taxis are an essential means that offer a fast, convenient and direct transport service in most urban areas (Yang & Wong, 1998). Taxis provide timeliness, door-to-door service, safety, convenience, high city space coverage and daytime availability and are now an inevitable part of any big city's communication system. This is due to the above-described advantages, despite the higher travel costs (Flores-Sanchez et al., 2011).

Thus, today, taxi information management has started to develop (Martinez & Viegas, 2017). The popularity of taxi applications is an advanced technology and a pricing strategy (Wang et

al., 2016). The expected profit that the taxi driver expects to receive from meeting a client in a particular area or place greatly influences the choice of a taxi driver for a location in the search for clients (Yang & Wong, 1998). A taxi passenger is looking forward to spending a few or a dozen minutes waiting for an empty taxi at the fast pace of life today (Cervero & Golub, 2007). Therefore, taxi companies are actively working to improve the vehicle distribution system so that taxis can drive the shortest possible route by carrying as many passengers as possible.

Nevertheless, it could easily lead to increased road traffic, thus leading to traffic congestion (Delli Carpini, 2000). Therefore, for any taxi company, the issue of deciding an appropriate number of taxis in disposal seems to be crucial. It should be a trade-off between the passengers waiting for a taxi and the income earned (Król & Król, 2019).

We all know that the population pressure on the road is increasing day by day, and it is inevitable that in the future, matters will worsen, affecting people's daily lives. Thus, taxi management and its study have massive importance for people of the city and to authority holders as well (Janeiro et al., 2011). One thing is for sure that in the future, more vast management planning will be required for effective road management and the benefit of people in Kathmandu (Ibrahim et al., 2018). Though studies have been conducted in the area in different parts of the globe, it is still not observed in Kathmandu Valley.

It is generally accepted that the taxi market is unique and requires restrictions that few other markets do. But many markets have particular problems, and few have draconian entry and price rules considered necessary (Are et al., 2006). To improve the taxi fleet service performance, ideally, we should simultaneously and optimally assign a taxi to service all customers' orders that are made within the time frame (Seow et al., 2010). Workplace hazards were a primary concern in the taxi industry, and management was actively involved in reducing the dangers faced by taxi drivers (Machin & De Souza, 2004). To simulate this transportation problem, three main actors in the primary operations of the system, namely: passengers, a service provider, and a road transportation network, are involved (D' Orey et al., 2012).

Taxi management means the proper organization of the road transportation system (Logan & Molotch, 2013). To be specific, taxi management would suggest utilizing the least resources in a sustainable process to bring proper management procedures in the transportation management sector. Time is also saved, and all available resources are used effectively and efficiently. Therefore, widespread problems in transportation are solved (Wong & Evers, 2010). The consequences of transportation mismanagement would lead to excess and unwanted resources, increase in accidents, traffic jams, environmental, noise pollution, etc. Hence, it is essential to learn about traffic management needs in the Kathmandu valley (Newman & Kenworthy, 1996).

Taxis fill an essential hole by offering transportation when riding or whilst other public transit modes are generally unavailable. As a result, it serves as supplementary public transit and as an alternative for public transit. Taxi services can pick up passengers precisely where they are standing and drop them off precisely at the desired destination without being bound to a predetermined path. This indicates that Taxi services are flexible in terms of route operation and easy accessibility. However, taxi drivers these days are facing issues due to

various advancement acquired by customers from various sources such as Pathao, Tootle and similar service providers. Thus this study tries to portray the picture about the current scenario of taxi drivers identifying the gaps existing in the market. Likewise, awareness of taxi drivers on taxi management is crucial for effective functioning of the service thus it is analyzed in this study to highlight whether taxi drivers are aware or not on taxi management in valley. Therefore this study aims to analyze challenges on taxi management in Kathmandu valley from the perspective of taxi drivers. Likewise awareness level of taxi drivers on taxi management, managerial solution to overcome the challenges are also identified.

The other part of this study is organized as the second section includes literature review. Third section comprise of research methodology, followed by results in the fourth part and finally last section concludes the study.

2. Literature Review

2.1. Opportunities and Challenges on Taxi Drivers

The combination of factors indicated that at least 13,000 jobs or 26,000, using existing taxi numbers could be created at minimum cost to the country. Lowitt conclusions emphasize that opportunities to generate appointments with little effort and cost in a country with high unemployment rates are rare. Still, the metered taxi industry offers such an option (Facey et al., 2016). Feasible and appropriate improvement measures to broaden the taxi trade's business opportunities, and at the same time, benefit the public through the provision of competitive taxi services in Hong Kong, China (Mueller et al., 2015). Cities comparable to Hong Kong in economic activities, such as Singapore, Tokyo, London and New York, were visited to study their regulatory mechanisms for taxi services and learn how their taxi systems are operated. On the operators' side, entrepreneurial opportunities, particularly for minorities and immigrants, were emphasized. On the other hand, an argument favoring government regulation is that it is necessary to correct market imperfections. Among the market imperfections that would require code are, for example, economies of scope and scale that lead to uncompetitive conditions in the dispatch market (Schaller, 2007).

Even though being a taxi motive force is simple in concept – day-to-day power a car and pick out-up passengers, drivers' customary working conditions can be unreliable. There are some key issues that taxi drivers around the sector face. Taxi drivers don't earn an ordinary wage or fee a set hourly charge. Alternatively, they're paid day-to-day on the range of fares they get; therefore, the intention is daily getting as many fares as feasible (Laurier, 2004). Drivers usually use a meter daily to charge passengers primarily based on time and distance travelled and some other days, just like the day they are driving. Taxi drivers are sufferers of crime more often than the average man or woman daily the character in their paintings – they paintings in all parts of a town, often late at night, and pick up random folks who may be inebriated, on pills or simply searching out hassle. Taxi drivers often work 8-12-hour shifts or longer, and they're sitting off their cabs for a great deal of this time. Taxi drivers can be everyday health troubles due to their limited movement day-to-day being in the sitting function for hours on giving up and their diets. They regularly devour numerous speedy meals at the run (Yuan et al., 2011). Taxi drivers face the similar everyday problems that all automobile drivers face – day-to-day, ruin downs, awful weather and different day-to-day

associated issues and fines. Those issues are amplified for taxi drivers as they're in their motors and a good deal more on the road than the joint driving force (Yuan et al., 2013).

2.2. Roles of Government in Taxi Management

The persistent public transportation syndicate has suffered significant setbacks. However, the current administration has taken a number of aggressive steps to end delivery entrepreneurs' monopoly. With the commitment of the transport minister to stop the syndicate existing in a taxi and a similar approach of travel, the high-quality message has been circulated amongst the general public. Based on the cutting-edge progress of the government, it will be wise to trust that the state of affairs can exchange for other sectors too. In fact, that is the maximum seen sign proven using the existing government to deliver in movement what it has promised indeed. At the same time as the past governments had also reiterated the significance of finishing syndicate, no concrete actions had been taken. Even the superb court docket's choice some 18 years in the past had ordered to eliminate this system.

Furthermore, in rare situations when the bureaucracy improved to punish the dishonest transport marketers, political patronage always came to their rescue. On the contrary, the proper coordination among the bureaucrats and the authority's ministers has borne visible culmination. With the branch leader of the shipping control publicly lauding the prevailing cabinet for lending help, in his flow of bringing the monopolists under the area of the countrywide regulation, the authorities' intention has come to be apparent (Shrestha et al., 2013).

Taxi management solution propels entries operation of Taxi Fleet any point of contact whether its customer, driver, process, dispatch, job handling and execution, vehicles tracking, maintenance, call center, payment collection, account every one catches a significant shift in reducing mishandling and overall delivery time. Taxi Ride fleet management software offers a set of comprehensive solutions to meet all of your fleet management needs. From reservations to tracking to driver payments, Taxi Ride gives you the tools you need to operate efficiently and effectively. It is a powerful tool that can streamline your business processes, increase profits and tips, and boost both rider and driver satisfaction, all while saving you hard-earned money (Pillac et al., 2013).

2.3. Taxi Business in Nepal

Taxi cabs play a big characteristic within the transportation enterprise. People choose taxis due to a ramification of motives inclusive of comfort and exclusiveness. Beginning a taxi business enterprise is a completely practical assignment. It is pretty rewarding. The quantity of capital required for starting the taxi business enterprise is predicated upon the dimensions of the commercial organization. It all relies upon what you need to attain and the property that you have (Toiskallio, 2000). While starting a taxi cab commercial enterprise, most of the capital will obtain taxi cabs. You may get a mortgage from the bank, or funding from traders, to use as capital to begin your meter taxi commercial enterprise. The marketplace for taxi cab offerings could be huge. There are a variety of capacity customers for taxi services. Agencies may additionally outsource transportation of their personnel to taxi cab organizations (Schaller, 2007b).

Famous taxi offerings like Uber and Ola are recognized to come to Nepal. In keeping with the latest reviews from different Media, those taxi experience sharing apps and services are eyeing the Nepalese marketplace to avail their services. They're currently studying the feasibility of their taxi cab services in at least the capital metropolis, Kathmandu. And then, Uber Ola taxi carrier may reach right here inside the capital metropolis Kathmandu (Sharma, 2018). We can't tell precisely whilst the Uber, and Ola taxi services will be to be had right here in Nepal. Because the information for the Uber launch in Nepal is older, we can assume they to return right here quickly. But you by no means recognize if Ola from the nearest neighbour India is right here first. Different or much less the equal sort of environment on this a part of the sector may favour Ola cab to regulate their carrier without problems (Keong, 2015). We've already posted or assembled some of the taxi apps, ride-sharing apps right here in Nepal. If Uber or Ola comes right here anytime quickly, it will be a breakthrough inside the current situation of the online taxi cab calling and paying carrier. Among them, Tootle's taxi bike app is quite popular, thinking about the supply of bikes in unique elements of Kathmandu (Hall, Palsson, & Price, 2018).

Taxi management solution propels entries operation of Taxi Fleet any point of contact whether its customer, driver, process, dispatch, job handling and execution, vehicles tracking, maintenance, call centre, payment collection, account every one catches a significant shift in reducing mishandling and overall delivery time. Taxi Ride fleet management software offers a set of comprehensive solutions to meet all of your fleet management needs. From reservations to tracking to driver payments, Taxi Ride gives you the tools you need to operate efficiently and effectively. It is a powerful tool that can streamline your business processes, increase profits and tips, and boost both rider and driver satisfaction, all while saving you hard-earned money (Pillac, et al. 2013).

3. Research Method

3.1. Study Area

The study area for this research is Kathmandu Valley. Being the country's capital city, Kathmandu valley is Nepal's commercial and economic hub. Kathmandu valley lies between the latitude of 27°32'13" and 27°49'10" north and longitudes 85°11'31" and 85°31'38" east (Adhikari et al., 2021). People across the country come to Kathmandu for education, employment, business, official works and many other foreign diplomacies. Also, being only a single international airport located at Kathmandu valley, travelers going abroad for many reasons and coming back home need to first get into Kathmandu valley and then only be allowed to be at their destination. All these activities have increased the demand for transportation in Kathmandu valley. For passengers who want to have a fast and reliable route, a taxi is the most convenient public transportation readily available at their doorstep. In most circumstances, people generally tend to travel via taxi in Kathmandu valley, and taxi affords a safe and handy opportunity for public transportation. As a result, over the last couple of years, a few startups have attempted to capitalize on the cab hailing offerings by making it comfortable and convenient for Kathmandu's commuters.

3.2. Study Population, Sampling Technique and Sample Size Determination

The population for this study is taxi drivers. As this study aims to identify challenges faced by taxi drivers working in Kathmandu valley, the entire taxi drivers' working day and night

are the study population of this study. According to the transport management department, around 10000 taxis operate in Kathmandu valley (Department of Transport Management, 2019). Thus, drivers working on those 11000 taxis are the study population for this research. This study uses a non-probability sampling technique as the drivers' list, name and identities are not well captured and maintained by the department. Since taxi owners decide to appoint and operate taxi in Nepal, it is hard to capture all the taxi drivers, which leads to convenient sampling. Thus, this study follows convenient sampling. The formula used to work out the sample size for the survey is $n = N * X / (X + N - 1)$, where $X = Z_{\alpha/2}^2 * p * (1-p) / MOE^2$, and $Z_{\alpha/2}$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96) (Paudel et al., 2020), MOE is the margin of error (undertaking for 5%), p is the sample proportion (50%), and N is the population size (11000). Calculating sample size based on this formula is 371. Thus this study has undertaken 386 taxi drivers' responses.

3.3. Research Instrument

The research instrument for this study is expert opinion and survey through a questionnaire. For an expert interview, a researcher frequently visited the Ministry of Transportation and the Department of Transportation from the beginning to the end of the study. While visiting the ministry, the researcher mainly consulted Kedar Prasad Nepal and Deepak Kumar Bhattarai, who provides necessary information and data and shared their thoughts about taxi management. Similarly, structured questionnaires are prepared to complete the survey, which consists of seven different sections. The questionnaire is designed as per the objective of the study. After the questionnaire was finalized, they were deployed into Kobo toolbox, which is an easy way if filling the questionnaire through mobile. Once the process was done, a Pre-test was done with 20 respondents (5% of the population determined) to confirm whether the given questions provided sufficient information or not. After the pre-test, certain modifications and additional questions were added to obtain more useful information from the respondent, specifically the user. The data collection was made based on face to face interviews. Due to the COVID-19 Pandemic effect, it took three months to collect the data. Data were collected from face-to-face interaction with respondents making necessary precautions suggested by the government.

3.4. Data collection and Analysis Techniques

For this research, descriptive analysis and index were prepared. Descriptive statistics are used to define the collected data's main structures quantitatively and examine the taxi driver's perception of the taxi management. Data were further analyzed and presented with the help of a bar diagram, pie-chart and tables. Similarly, Taxi drivers' perception and readiness index are prepared. To measure the perception of the taxi driver, 10 questions are designed among them emotionally (2), traffic rules related (2), Customers' service-related (2), Government rules related (2) and behavioural related (2) are asked. Similarly, to measure readiness total of 6 questions related to taxi drivers' Experience, attention and health are kept forward. As it is calculated on the Likert scale, they are considered highly aware if score value is more than 80%, knowledgeable if score between 60% to 80%, moderate if score 40% to 60%, less aware if score 20% to 40% and significantly less aware if score less than 20%.

4. Result and Discussion

4.1. Socio-Demographic Characteristics

Among 386 taxi drivers surveyed for the study, 100% of respondents were male, which means most taxi drivers are male to date in Kathmandu valley. 58% of respondents were from Kathmandu valley, 28% from Bhaktapur and 14% from Lalitpur. Maximum respondents' are from age group 35-45 years, i.e. 52.49% and drivers from age group 15-25 years lease, i.e. 2.34%. So, it can be understood that most of the people who drives taxi are in-between age of 35-45.

Table 1 depicts that 49% of taxi drivers have a monthly income of between 20,000 – 30,000 NRs. 12% stated that they earn around 30,000-40,000 monthly, and 6% said they make up to 20,000 monthly. This study revealed that the maximum (49.22%) drivers in Kathmandu valley have 5-10 years of driving experience. There are no such educational requirements for drivers in Nepal. However, they must obtain a drivers' license. When asked about the academic level of drivers for this study, it was unleashed that 61.66% drivers had studied up to intermediate level and 3.11% of drivers hold master's degree.

Table 1. *Socio-Demographic Characteristics*

Socio-Demographic Characteristics	Frequency	Percentage (%)
Gender		
Male	386	100
Female	0	0
Age (in years)		
15-25	9	2.34
25-35	97	25.13
35-45	203	52.49
45-55	77	19.85
Monthly Income (NRs.)		
Up to 20,000	23	6
20,000- 30,000	189	49
30,000 – 40,000	127	33
40,000 – 50,000	47	12
Driver's Experience (in years)		
1-5	47	12.18
5-10	190	49.22
10-15	75	19.43
More than 15	74	19.17
Education		
Illiterate	80	20.73
Intermediate	238	61.66
Bachelor's	45	11.66
Masters'	12	3.11
Others	11	2.85

Source: Field Study

4.2. Status of Taxi Drivers

A taxi driver's shift may be very busy or slow, based on the area in which that driver is working. How active the transformation is and how many fares the driver collects will determine the pay structure for each day. Among 386 taxi drivers, 95% stated that they drive taxis daily, whereas 5% said they don't drive taxis regularly. Those who don't drive a taxi regularly drive it on alternative days, i.e. 50% drives five days a week, 20% drives three days a week, and 30% drive according to their convenience. 52.85% of drivers prefer to drive a taxi at day time, 2.85% prefer to drive a taxi at night, and 44.30% prefer to drive a taxi at both times, i.e. day and night. They further stated that some of the motivating factors to drive taxi during the night are: they get extra fare at night (30%), encounter less traffic and jams (20%), and 50% stated that as they do another job as well as drive taxi as part-time service, they prefer driving a taxi during night times.

As 171 respondents prefer to drive a taxi at both times, i.e., day and night. 83% of drivers stated that they are comfortable working alone for long hours, and 17% of drivers are not satisfied to work alone for long hours. Drivers can work long hours, but that must be governed by law, and drivers must practice driving as per the country's law. Briefly, after 5 hours of driving, you must take a minimum break of 30 minutes or 45 minutes in any period of 8 hours. You mustn't work more than 16 hours, and then there is a compulsory break of 10 hours. Similarly, the study also revealed that drivers themselves own 54.66% of the taxi. 31.87% of drivers have taken a taxi on the lease, 10.62% of drivers hire a taxi from owners and drive for them, and 2.85% stated that they use taxis from various other sources.

Likewise, we often hear news of various issues between taxi drivers and customers. The conflict between them may occur due to multiple reasons. This study unleashed that 59% of the taxi drivers have been threatened while driving the taxi by their customer, and 41% of the taxi drivers have not been threatened by the customer while driving the taxi. This shows their customers have threatened the majority of drivers. If drivers had proper knowledge about taxi management, they would easily handle the situation. It was depicted from the study that 60% taxi driver knows about taxi management in Nepal whereas 40% taxi drivers don't know about taxi management. From this, we can say that maximum drivers know about taxi management in Nepal.

Figure 1 depicts that 83.68% of taxi drivers considered that passenger's safety is essential for them. In contrast, in driving, 3.63% of drivers responded they are moderately concerned about passenger's safety, and 12.69% responded that passenger's safety is quite essential for them while driving the taxi. 55% of the respondents use an online platform, and 45% do not use an online platform. From the data, we can state that many respondents are aware of the online platform, but many respondents still need to follow the current trends. Out of the total respondent, i.e. 386, 52, i.e. 24% respondents are using Tootle, 143, i.e. 67% respondents are using Pathao, and 19, i.e. 9% of the respondent are using Sarathi. The majority of drivers seems to be using Pathao rather than another platform.

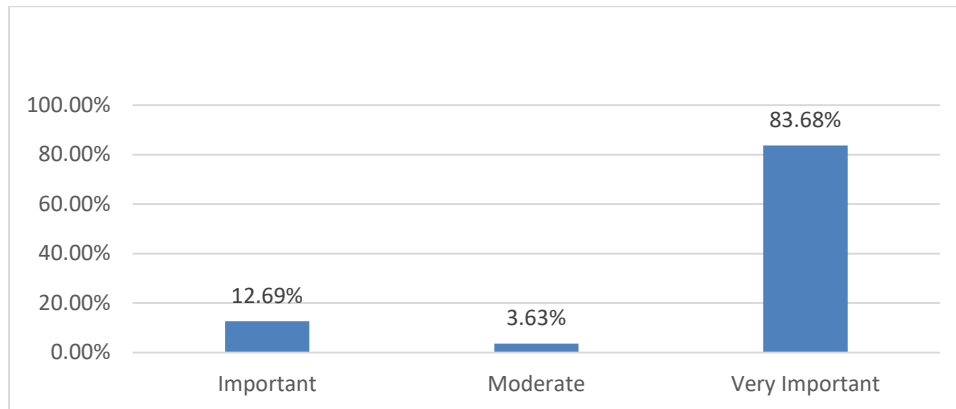


Figure 1. Passenger's Safety Considered by Taxi Drivers

4.3. Awareness Level

The awareness level in this study depicts the awareness level of taxi drivers towards taxi management in Kathmandu valley. It also showcases the perception of taxi drivers on taxi management. This section classified the awareness level as emotional, traffic, customer services, government, and behavioural aspects. It helps us to know how healthy taxi drivers know about taxi management.

Under the Emotional dimension, respondents were asked about their awareness of travelling new routes and drivers' awareness of driving safely at night. While asked upon their understanding on travelling to new route 1.81% drivers are extremely low aware, 17.36% are quiet aware, 39.12% are moderately mindful, 38.86% are highly conservative, and 2.85% are extremely high aware. Likewise, when asked about taxi drivers driving safely at night, 2.59% of drivers are extremely low aware, 29.02% are pretty mindful, 26.94% are moderately conservative, 41.19% are highly conscious, and 0.26% are extremely high aware.

Further, regarding the government rules, it was classified as awareness of taxi stand management and drivers following rules and regulations prescribed by traffic. Table 2 under the Traffic rules dimension suggests that 2.33% of taxi drivers are extremely low aware, 29.53% are pretty mindful, 18.65% drivers are moderately conservative, 46.63% are highly conscious, and 2.85% are extremely high aware regarding taxi stand management in the valley. Similarly, 0.78% of drivers are extremely low aware, 22.80% are pretty mindful, 30.05% are moderately conservative, 44.56% are highly knowledgeable, and 1.81% are extremely high aware of rules and regulations to be followed, taxi drivers.

Under the customer services dimension, 3.63% of drivers are extremely low aware, 27.72% are pretty mindful, 33.42% are moderately cautious, 33.94% are highly conservative, and 1.30% are extremely familiar comfortable interacting with customers. Also, 2.85% of drivers are extremely low aware, 30.31% drivers are pretty mindful, 18.65% drivers are moderately cautious, 46.11% drivers are high, and 2.07% are extremely high awareness regarding the frequency of customers. On a similar note, under standard meter rates provided by government, drivers feel that 24.87% of drivers think a poor understanding of it, 43.78% are pretty aware of it, and 12.18% are moderately 17.62% are highly mindful, and 1.55% are extremely high aware.

Talking about rules and regulations of the government, it was found that 29.27% of respondents are extremely low aware, 40.67% are pretty mindful, 11.92% are moderately conservative, 15.80% are highly conscious, and 2.33% are extremely highly aware. Regarding the behavioural aspect, 3.11% of drivers think they are extremely low aware regarding it, 23.32% are low mindful, 13.47% are moderately conservative, 58.55% are highly conscious, and 1.55% are extremely highly aware.

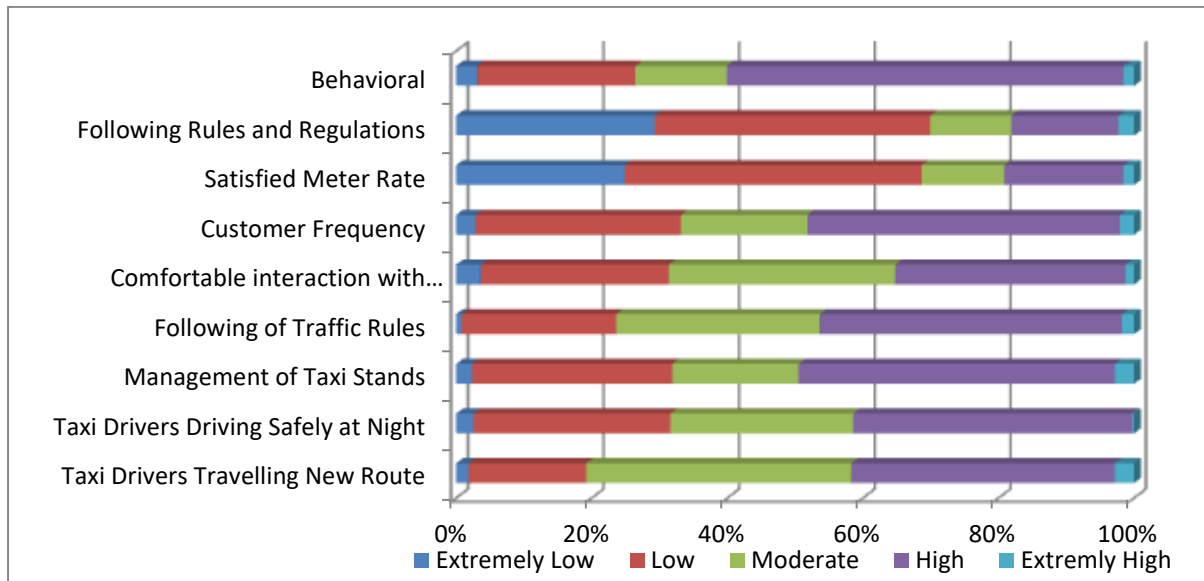


Figure 2. *Taxi Drivers' Awareness Level*

4.4. *Challenges in Taxi Services*

Taxi drivers witness various challenges daily, as we can hear from multiple sources as well. Likewise, this study also indicated that 77% of taxi drivers had faced difficulties in taxi services, while 23% stated they had not faced any challenges while driving a taxi. Taxi Drivers across the world operates in a mobile environment that challenges the traditional concepts of the workplace. They provide 24x7 services uniquely tailored to individual travel's requirements, a feature not supplied by other means of public transportation.

The challenges faced by taxi drivers are similar services provided by online vehicle platforms and an increase in the usage of private vehicles. Moreover, other problems include challenges arising from the government's rules and regulations and ill customer behaviour. Similarly, four significant challenges are pointed by taxi drivers that they face in taxi services in this study which includes; increase in usage of private vehicles and easy access to public transportation, government policies, online vehicle service provider platform and parking difficulties.

Among the majority of the above-stated challenges (32%) of drivers stated that increase in usage of private vehicles and easy access to public transportation has been a significant challenge for them as people opt to use private or public vehicles before choosing a taxi and they don't prefer taxi over private and public transportation unless it is emergency. Likewise,

24% of drivers stated that they face parking problems to a greater extent. The emergence of online vehicle service providers has emerged as a new challenge for them. People find those services easy and convenient rather than waiting and searching for a taxi respectively. 20% of drivers revealed that the rules and regulations set by the government for taxi and its driver are challenging.

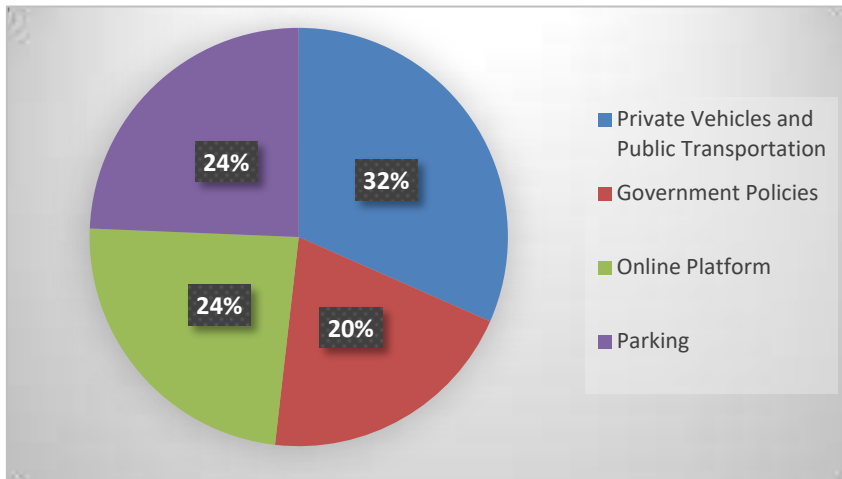


Figure 3. *Challenges*

As drivers responded, public and private vehicles get lots of customers as they charge a lower rate than taxi services as they do not have to pay taxes that taxi services have to pay, so taxi drivers see them as a challenge. Due to various government policies and the low meter rate provided by the government, it isn't easy to stay in the taxi business. As we can see, nowadays, many online platforms like Tootle, Pathao are providing transportation services to the customer. They charge low prices. With the help of technology, they have created challenges to taxi services. Lastly, the lack of parking facility in the crowded area has to charge high prices, so the customer refuses to use taxi services.

4.5. Managerial Solution and Way-forward

Suggestions to Manage Challenges

As most (77%) of the drivers were facing challenges in taxi services in Kathmandu valley, those challenges could be mitigated with productive efforts. Thus, drivers were further asked if those challenges were manageable or not, for which 73.83% of drivers stated that such problems might be managed if taken care of properly and tremendous effort are given from respective responsible sides. For instance, the need to continuously improve their service providing while reducing their charges has caused many logistics and transportation companies to install GPS devices in their complete vehicular fleets. These gadgets permit the agencies to reveal the movement of their fleet in real-time and use that data to improve their fleet's efficiency, reliability, and security. The availability of GPS traces from these fleets has also allowed researchers to inspect various topics associated with planning, mobility, efficiency, and other areas involving vicinity traces (Sen & Balan, 2013). If similar other efforts are made looking upon the challenges, challenges might be mitigated to a certain extent.

Figure 4 portrays managerial solutions for challenges faced by taxi drivers. 30.05% stated that it is possible to manage taxis by providing GPS services in the taxi to locate their customers who need a taxi. 14.51% mentioned it is possible to manage taxis by giving route permits. 16.58% said that it is possible to manage taxis by introducing new policies by the government that favour taxi drivers. 7.51% responded by providing proper training to help manage taxis, and there will be a fewer traffic problems. Lastly, 31.35% mentioned if there are better parking facilities it will be helpful to manage taxis.

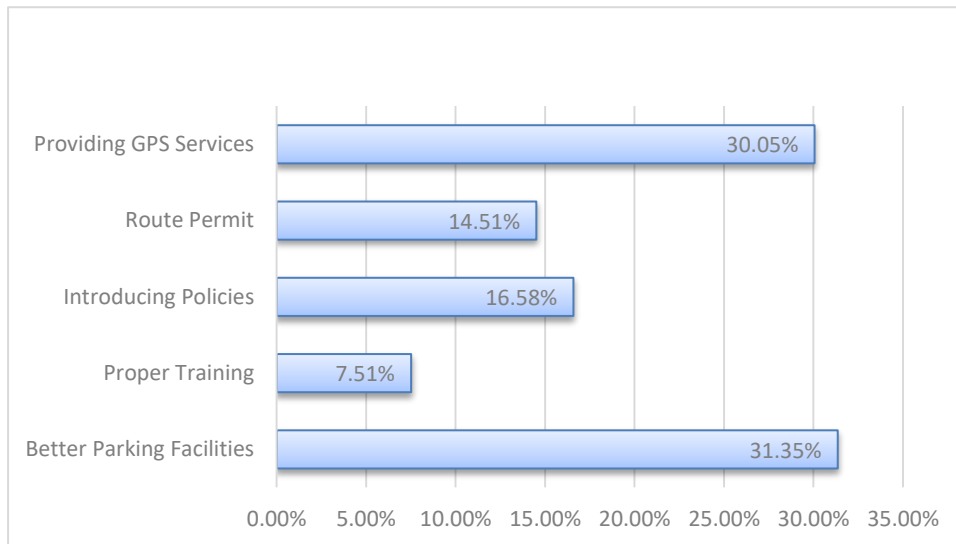


Figure 4. *Managerial Solutions for challenges faced by taxi drivers'*

Suggestion to Manage Taxi

14% of drivers responded those taxi owners have to work with committed drivers to take care of taxi services properly. 11% stated that drivers should view things from customer points and try to understand them, 41% suggested targeting the audience based on location helps them reach the maximum number of customers.

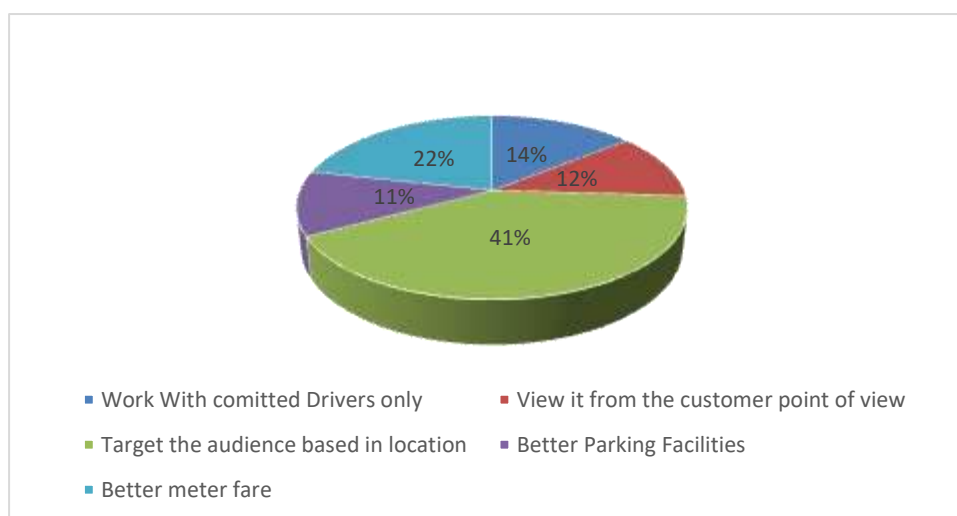


Figure 5. *Suggestion for Taxi Management*

They should target areas with a more significant inflow of people. Similarly, 11% suggested that there should be better parking to help them with traffic in crowded places. Lastly, 21.50% indicated that the government should regulate better meter fares.

On a similar note, as defined by the industry forerunners, a typical taxi management software should have separate mobile or web applications for passengers, drivers, dispatchers, and admin. So that passengers can book their cab from their application, the same can be notified via the driver app. Employing the dispatcher app, the dispatchers can assign cabs and drivers and dispatch vehicles for bookings. Likewise, the admin or the business owner can track all the processes in real-time.

5. Conclusion

As this study discusses challenges that taxi drivers face in taxi management, the study found that 77% of drivers face challenges in the Kathmandu valley. Pieces of training, better policies, and a GPS are some solutions that could help mitigate the challenges. Likewise, drivers' commitment towards enhancement of taxi management, targeting audience based on location, and improvising meter fares could further help the overall taxi management process. Additionally, it was also concluded that if the government could make policies that are drivers friendly and promote taxi management, it would enhance the overall system effectively. This study would be useful to policy makers and concerned authorities in the field of taxi management and taxi drivers as well to make strategies on minimizing challenges arising in the field.

Therefore, this study recommends policy makers and responsible authorities consider a strategy to improvise the overall taxi management system in the valley. If the taxi management system got effective, that would be an encouragement for other vehicle management. Likewise, drivers should also try to cope with customers. Customers should also behave well and treat healthy drivers as cooperation between both will be helpful for management of taxi service to the greater extent. Also, this study was conducted in Kathmandu valley only due to several constraints; therefore, further study could include other parts of the country where taxi mobility is high. Only descriptive part is incorporated in this study, so another study of a similar kind is possible with inferential research. Some variables might be missing that would strengthen the study, so proper analysis of variables can be made, making this study more assertive in the future.

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Credit Risk Management and Sub-Standard Loans of Commercial Banks in Nigeria: A Panel Data Analysis

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Abstract

This study examined the effect of credit risk management on sub-standard loan portfolio of quoted commercial banks in Nigeria. Cross sectional data was sourced from financial statement of commercial banks and Central Bank of Nigeria Statistical bulletin from 2009-2018. Sub-standard portfolio was used as dependent variable while bank risk diversification, Basel risk compliance, risk transfer were used as independent variables. Panel data methodology was employed while the fixed effects model was used as estimation technique at 5% level of significance. Fixed effects, random effects and pooled estimates were tested while the Hausman test was used to determine the best fit. Panel unit roots and panel cointegration analysis were conducted on the study. The empirical results proved that 41.7 per cent variations in the sub-sub-standard loans' portfolio was explained by credit risk management. From the random effect results, bank risk transfer and Basel compliance have positive relationship with sub-standard loan portfolio while risk bank risk diversification have negative relationship with sub-standard loan portfolio of the commercial banks. We recommend that management of the commercial banks should be pro-active and devise effective measures of managing credit risk to reduce the incidence of sub-standard loans. The monetary authority should monitor the Basel compliance rate and policies of the commercial banks to credit risk management.

Keywords: Credit Risk Management, Sub-Standard Loans Portfolio Commercial Banks, Nigeria, Panel Data Analysis

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1. Introduction

Bank is a financial institution which business involves the management of assets and liabilities. Unlike other business organizations such as the manufacturing that stock tangible goods as inventory, the inventory of the banking sector is the stock of money. This means that bank trade on Money (Ezirim, 2005). By its nature bank face number of challenges within internal and the external business environment, the Nucleus of banks is intertwine with risks which including credit risk, market risk, interest rate risk operational risk (Aruwa and Musa, 2014). Basically,

bank operates with three basic objectives which are profitability, growth of assets and customer base.

In Nigeria, Banks and Other Financial Institution Act 1990 (BOFIA) as amended regulate banks operation and restrict its investment in certain business, this is complemented by the provisions of BASEL I, II and III for effective management risk in bank business to mitigate effects on the safety and stability of the banking industry. Poor credit risk management can result in non-performing loans, high provisioning of loans and gross lending related insider abuse are among the major challenges facing Nigerian banks in assets management.

One of the challenges facing Nigerian Banking Industry in the past three decades is the mismatch of assets and liabilities as a result of sharp practices, over trading and insider related practices (Soludo, 2007). The banking sector crisis of 1990's and 2000's could be traced to poor credit risk management. Central Bank of Nigeria Examination team in 2009 discovered that four years after the consolidation, some banks were functioning in danger of near collapse, this led to the injection of ₦620 billion and the establishment of Assets Management Corporation of Nigeria (AMCON). The above questions the relevance of capital adequacy rather than management and assets quality of a bank.

Demirguc-Kunt and Detragiache, (2016) noted that credit management involved the management and administration of risk that are embedded in credit. However Dionne (2013) defined risk as the potential that events, expected or unexpected, may have an adverse impact on the Loan Management. It is important that loan administrators understand all the risks embedded in the loan administration and formulate strategies to manage it. Banks have to develop and implement comprehensive procedures and Information systems to follow up the condition of individual credits. An effective loan monitoring system according to Odufuye (2007) includes measures to monitor compliance with established covenants, assess, where applicable, collateral coverage, relative to creditor's current condition, identify contractual payment delinquencies and classify potential credits on a timely basis, and direct actions at solving problems promptly for remedial management. There are many studies on credit risk management, significant proportion of the study focused on credit management and commercial banks profitability. This study examined credit management and the effect on sub-standard loans of commercial banks in Nigeria.

2. Literature Review

2.1. Credit Risk Management

Credit management is a procedure banks adopted in the mitigation or reducing the negative effect of credit risk. A comprehensive credit risk management structure is vital because it helps increase the revenue and survival. According to (Singh, 2013) sound credit-giving is one of the most essential principles which strengthen financial institutions in their financial standing. Sound credit management, giving establishes credit limits as well as develop credit granting process for approving new credits will ensure reduction in credit default. Credit plays a very vital part in the economic growth and development of a country. These roles credit plays can be categorized into two: it enables the transfer of funds to where it will be most effectively and efficiently used and

secondly, credit economizes the use of currency or coin money as granting of credit has a multiplier effect on the volume of currency or coin in circulation.

Singh (2013) noted that Credit management means the total process of lending starting from inquiring potential borrowers up to recovering the amount granted. It is noted that, in banking sector, credit management is concerned with activities such as accepting application, loan appraisal, loan approval, monitoring, and recovery of non-performing loans. Credit risk management described credit management as methods and strategies adopted by a firm to ensure that they maintain an optimal level of credit and its effective management, it is an aspect of financial management involving credit analysis, credit rating, credit classification and credit reporting.

2.2. Credit Risk Management Strategies

This study identifies credit risk management from the perspective of risk diversification, Basel compliance, risk transfer, credit monitoring and appraisal.

2.2.1. Risk diversification

Bank loan portfolio diversification strategies are based on the modern portfolio theory of Markowitz (1952), and largely followed by experts in financial institutions (Winton, 1999). According to the idiosyncratic risk hypothesis, diversification eliminates the specific (idiosyncratic) risk which enable banks to reduce their monitoring efforts and therefore lower their operating costs, which ceteris paribus should lead to higher cost efficiency (Rossi et al., 2009). Furthermore, the benefit of diversification stems from economies of scope across inter alia economic sectors and geographic areas (Laeven and Levine, 2007). Researchers like Berger et al.(2009) and Tabak et al. (2011) all indicate that risk reduction and performance improvement are advantages of diversification whilst agency problems are common associated disadvantages.

Diversification is a portfolio strategy designed to cut back risk by combining various investments. Diversification gain from shifting into non-interest income in bank's revenue and reduced volatility of bank profits (Stiroh, 2004). In investment planning and finance, diversification improved cost influence through lower risk from diversification if it occurred; it lowered the needed risk premiums on un-insured debt. Income supply diversification refers to banks shifting their financial gain sources into non- intercession financial gain generating activities as opposed to the normal inter-mediation financial gain generating activities.

2.2.2. Basel compliance

The Basel Accord is international principles and regulations guiding the operations of banks to ensure soundness and stability. The Accord was introduced in 1988 in Switzerland. Compliance with the Accord means being able to identify, generate, track and report on risk-related data in an integrated manner, with full audit ability and transparency and creates the opportunity to improve the risk management processes of banks. The New Basel Capital Accord places explicitly the onus on banks to adopt sound internal credit risk management practices to assess their capital adequacy requirements (Chen and Pan, 2012).

Basel I Accord was introduced in 1988 to the member of Basel to agree upon application of capital adequacy ratio that stabilizes banks based on four pillars. The First pillar is to introduce

Tier one and Tier two capitals which are summarized as follows: The main function of Tier one capital is to absorb any financial shock that may interrupt the banks from continuing their banking operation. This tier one capital consists of Banks' ordinary shares or what is also called Bank's equity excluding revaluation of bank's reserves.

Tier two capital is providing another protection that helps banks to absorb shocks in the market in case of bank's liquidation. However, Tier two capitals are offering a low level of defense for depositors and creditors. Tier two capital consist of the revaluation of reserves and provisions. The Second Pillar is the risk weighted system which composes the integrated procedure to allocate weight across different banks' assets. It pointed out five classes of assets that cover all banks assets in their balance sheets from zero to five points range. The description of each class depends on the valuation of each country's central bank.

The Third pillar is an aimed standard ratio for capital adequacies that link pillar one and pillar two together to present an agreeable standard to all banks (Adeusi, Akeke, Adebisi, and Oladunjoye, 2013). The minimum capital adequacy ratio (CAR) was 8%. This mean that 8% of total banks' risk weighted assets have to be covered by both Tier one and Tier two capital .There is a restriction for Tier one that it must cover at least 4% of total bank's risk weighted assets. However, If CAR is 8%, this does not mean that the bank is fully safe. The fourth Pillar is the application of the above-mentioned agreement. It puts a road map and phases to implement the agreement and it requires the central bank to have a strong and significant oversight system to ensure the application of Basel Accord.

Criticism of Basel I

Basel I has been criticized in many aspects. One of the most significant criticism is its weighting system. As in Basel-I the risk weighting system is described as a subjective bucket and an arbitrary structure due to its broadness (Chen and Pan, 2012). Also, the risk weighting system missed the sensitivity to the distinctive types of risks related to each asset held by the bank. Each bucket in the weighting system contains diverse assets with different risk level however all this asset has been contained in one bucket because these assets share same business counterparty. In the weighting system of Basel I all commercial loans are risk weighted for 100%. This weighting system is not logic and missed the reality of classifying commercial loan risk and its application (Dionne, 2013). As if the bank grant a commercial loan to a company with a very strong financial position the risk in this situation should be totally different when the bank grant a commercial loan to a newly established company.

Another criticism based on the shortcoming in Basel I is that the bank will select to grant loans to startup company due to its higher expected interest (Fan and Yijun, 2014). Accordingly from profitability aspect, granting loan to newly established company is much riskier and much profitable than granting loans to well-established banks. This gives the bank the chance no to well diversify its loan portfolio as the risk of all commercial loans are equal in the risk weighting system of Basel I.

Basel II

The above mentioned criticism to Basel Accord I incentives Basel Committee to re-evaluate the recommended procedures to ensure adequate capital adequacy ratio. It introduced the using of external agencies rating system and internal risk rating system to grade banks' assets. For instance, the risk weight of debt rated from A+ to BB+ is 50% while the risk weight of debts below B- is 150%. Pillar I is not covering credit risk only but other types of risks such as market based assets for example currency risk , shares and commodity trading risks.

Criticism of Basel II

Rating of the risky assets is based on external rating agencies. The critical issue is that banks are subjected to fees by agencies that rate them. This could culminate in self-interest threat for the agencies and create a rift between the bank and the rating agency. The use of faulty methodology by the rating agencies is yet another ground for criticism (Elisa and Guido, 2016). Such error-prone methods are used to assess and rate the risky assets such as securitized assets which lead to wrong and inappropriate risk weighting. The obvious example which supports this criticism is the high rating granted to securitize asset classes of some banks before the 2008.

Basel III

Based on Basel II framework, The Basel III accord has been introduced by Basel Committee and focused mainly on three main critical issues namely: Capital requirements, Leverage Ratio and Liquidity requirements. With regard to Capital requirements, The Basel Accord introduced two new capital requirements as follows: An obligatory capital Conversion ratio for 2.5% from risk weighted asset. And another 2.5 % as a counter cycle ratio that permit the national regulators to ask banks to fulfil these additional capital requirements in case of high growth of credit supply. Concerning the leverage ratio, Basel III introduced a new ratio called minimum liquidity ratio that calculated by dividing Tier one capital by average total Bank's Assets .Basel III sets 3% as a minimum leverage ratio to be maintained by banks.

Criticism of Basel III

The main criticism to Basel III is all about capital adequacy ratio (minimum capital Level). As the minimum accepted capital to be held by the bank has been increased from 8% to 13% after the failure of commercial banks to absorb losses happened during the recent financial crisis and its critical consequences. The most critical issue related to the minimum required level of Capital, is that as long as there is an increase in the capital level, this increase will lead to decrease in money supply in the market through commercial loans (Olweny and Shiphoo, 2011). In other words, Banks will decrease the level of loans to lenders which will result in decrease in the business activity and will have a negative impact from the macroeconomic point of view. In addition, the commercial banks may ask for high interest rate in order to compensate the difference between loan volume based on minimum required capital of Basel II and Basel III.

Further criticism to the consequences of increasing capital level is that in order to compensate the difference in loan volume, banks may select risky project to finance it in order to charge a high interest rate accordingly increasing the risk of the loan portfolio and affecting its stability in the future increase of any prospect financial crisis or expected financial market losses. The institute of international finance reports that the GDP will be affected negatively by

approximately 3.1% for each 1% increase in the minimum capital level required by Basel III. In the same perspective the Basel committee issue another report stated that the decrease in GDP is expected to be 0.09% for each 1% raise in capital level. Although there are differences between both report regarding the accurate figure that represent the decrease in GDP but the only fact is that there is a negative impact is expected to be happened to country GDP. There is an argument with regard to the effect on the profitability of the banks and the negative impact of GDP. This argument regarding the time required to apply the new required level of capital.

Basel III commenced full implementation of the new capital requirement in 2019; consequently, there was room for gradual implementation as regards the capital threshold. Additional critic to Basel III from another point of view is that some scholars examined the banks that had the ability to absorb the consequences and the financial shocks from the recent financial crisis. The results show that the minimum capital level of these banks vary from 15-20%. Accordingly comparing the minimum requirement by Basel III and the calculated real capital adequacy ratio of these banks, the result will confirm that the improvement required by Basel III concerning Banks' Capital is not sufficient enough to absorb any prospect shocks and financial losses that may occur in the future.

Another criticism to Basel III is that it does not introduce any solution the problem of Basel II such as using external rating agency to assess risk of banks' assets in addition to no solution also has been introduced regarding standardization of the methodology used by banks through internal rating-based approaches (Singh, 2019).

2.2.3. Risk transfer

It is the transfer of credit risk to a factor or insurance firm and this relieves the bank from monitoring the borrower and fear of the hazardous effect of classified assets. This approach insures the lending activity of banks. The growing popularity of credit risk securitization can be put down to the fact that banks typically use the instrument of securitization to diversify concentrated credit risk exposures and to explore an alternative source of funding by realizing regulatory arbitrage and liquidity improvements when selling securitization transactions (Michalak & Uhde, 2009). A cash collateralized loan obligation is a form of securitization in which assets (bank loans) are removed from a bank's financial statement and packaged (trenched) into marketable securities that are sold on to investors via a special purpose vehicle (SPV) (Marsh, 2008).

Sub -Standard

This form of loan advance shows a distinct loan weakness that endangers the insolvency of the debt incurred. It normally includes loans granted to debtors who are having cash flow element that is not enough in meeting the current maturing debt, loans to borrowers which are significantly undercapitalized, and loans to borrowers lacking sufficient working capital to meet their operating needs. Substandard loan advances are not secured by the current sound worth and paying capacity of the client. NPLs and receivables which are more or up to ninety days overdue but not up to the 180 days unpaid are also substandard loan. Thus loan advances become unpaid when the principal or interest component is due and unpaid for 30 days or more (Onoh,

2002). The following objective and subjective criteria should be used to identify sub-standard credit facilities.

Objective criteria: facilities as defined in paragraph of BOFIA (b) on which unpaid principal and/or interest remain outstanding for more than 90 days but less than 180 days.

Subjective criteria: credit facilities which display well defined weakness which could affect the ability of borrowers to repay such as inadequate cash flow to serve debt under capitalization or insufficient working capital absence of adequate financial information or collateral documentations, irregular payment of principal and or interest, and inactive accounts, where withdrawal exceed payments or where repayments can hardly cover interest changes.

This type of loan advances indicates all the weakness features shown in the substandard loan category with other added features that the loan are not well-secured and the limitation making the liquidation in full on the basis of the facts currently existing together with the conditionality, values which could be highly doubtful. Even though the probability of loss is very high, the existence of certain strong indicative factors may work to the advantage and strengthening of the repayment, deferring its estimated loss categorization until more exact status determined (Onoh, 2002). NPLs and receivables having 180 days or more unpaid period but not up to the 360 days unpaid period are classified as doubtful loan advance. The following objective and subjective criteria should be used to identify doubtful credit facilities.

- i. **Objective criteria:** Facilities on which unpaid principal and/or interest remain outstanding for at least 180 days but less than 360 days and are nor legal titled to leased assets or perfected realizable collateral in the process of collection or realization.
- ii. **Subjective criteria:** facilities which, in addition to the less strength associated with sub-standard credit facilities – reflect that full payment of the debt is not certain or that realizable collateral value will be insufficient to cover banks' exposure.

Loss are said to be uncollectible and of such little value that their continuation as recoverable advances is not warranted. However, this does not indicates that there is no recovery value of the loan advance, but the practicability to defer writing off this type of loan even though partial retrieval may be hampered in the future. This type of loan advance includes liquidated or insolvent companies with bad current asset and cash flow. Financial institutions should however not keep this loan advances within their records no matter the long term effort made in recouping the advances (Onoh, 2002). Losses should be taken in the period in which they surface as uncollectible. The NPLs and the receivables having the 365 days unpaid period or more are all termed as a loss.

The following objective and subjective criteria should be sued to identify lost credit facilities:

Objective criteria: Facilities on which unpaid principal and/or interest remain outstanding for 360 days or more and not secured by legal title to has assets a perfected realized collateral in the cause of collection or realization.

Subjective criteria: Facilities which in addition to the weakness associated with doubtful credit facilities, are considered uncollectible and are of such little reduce that continuation as a

bankable assets is unrealistic such as facilities that have been abandoned, facilities secured with unremarkable and unrealizable securities and facilities extend to judgment debtor with no means or for closable collateral to settle debts. Banks are required to adopt the criteria specific in paragraphs in PGBL classify them credit portfolios in true accounting value of their credit facilities. Licensed banks should note that the central bank of Nigeria reserves the right to object to the classification of any credit facilities and to prescribe the classification it considers appropriate for such credit facilities.

2.3. Theoretical Review

2.3.1. Modern portfolio theory

Markowitz (1952) Modern portfolio theory (MPT) is one of the most important and powerful economic theories dealing with finance and investment. The portfolio theory approach is the most relevant and plays an important role in bank performance studies (Atemnkeng & Nzongang, 2006). According to the Portfolio balance model of asset diversification, the optimum holding of each asset in a wealth holder's portfolio is a function of policy decisions determined by a number of factors such as the vector of rates of return on all assets held in the portfolio, a vector of risks associated with the ownership of each financial assets and the size of the portfolio. It implies portfolio diversification and the desired portfolio composition of commercial banks are results of decisions taken by the bank management.

2.3.2. The Balloon Loan Portfolio Theory

The Balloon Loan Portfolio (BLP) Theory is a postulation originated in this study as part of contributions to knowledge. The theory situates the practice of hiding, suppressing or covering up critically challenged loans in a bank's loan book, without disclosure, until the loans become extremely bad and possibly irrecoverable. Such credits could take the form of insider-related lending, name lending, policy lending or any other third-party loan that initially failed the Risk Asset Acceptance Criteria (RAAC) of the bank, but was nevertheless granted, under lower assessment standards, due to inordinate influence of the bank's executives. From another perspective, such loan could also be a good loan from the beginning, which passed through a stringent appraisal system, similar to the system described in the stringent lending theory (Kithinji 2017), but suffered declining performance due to environmental defect such as macro-economic recession, adverse fiscal policy, weak demand, loss of market or even unexpected adverse change in borrower's character.

When loan default persists for more than 90 days, banks are mandated to classify such loans as non-performing and make provision in line with the dictates of the Prudential Guidelines or loan impairment charge in line with the requirements of the International Financial Reporting Standard (IFRS) or write off the loan, in extreme cases. However, in view of the adverse effect of loan provision or impairment charge or absolute write-off on bank profit and capital, banks are often reluctant to take such steps, due to the primary objective of management to maximize profit, meet regulatory capital adequacy ratio and impress their shareholders. In order to hide such nonperforming loans from the eagle eyes of regulatory examiners, while loan recovery actions are in force, banks resort to loan restructuring, tenor extension, loan swapping, teeming

and lading or granting additional cover-up loan similar to the scenario described as zombie lending in the zombie lending theory, or indulging in other forms of loan workout arrangement. CBN (2015) corroborated these views stressing that the failure by some banks to report their nonperforming loans to the Credit Risk Management System (CRMS) at the CBN and the inability of others to confirm the credit status of intending borrowers before disbursing loans led to the increasing incidence of predatory borrowers. The ultimate effect of such cover-up action is to create a portfolio of balloon loans which would imminently burst, in due course and could end up in a devastating effect for the bank, its depositors, shareholders and other key stakeholders, depending on the size of the loan and its portfolio proportion.

2.4. Risk Management Theory

David (1997) developed this theory aiming to study why risk management was required, and outlines theoretical underpinning under contemporary bank risk management; its emphasis is on market and credit risks. The theory indicates that market and credit risks would have either direct or indirect effect on banks survival (Eichhorn, 2004). One would expect the credit risk indicators to influence banks profitability if there is no effective and efficient credit risk management (Ngugi, 2001). This theory identifies major source of value loss as Market risk being a change in net value of asset due to change in interest rate, exchange rate, equity and commodity prices (Wu and Olson, 2010). Regulators are concerned with overall risk and have minimum concern with individual risk of portfolio components as managers are capable of window dressing the bank position. The need for total risk show that measurement of risk cannot be centralized as risk of a portfolio is not just a sum of component as per Markowitz theory. This implies that portfolio risk must be driven by portfolio return which is invariant to changes in portfolio composition. Regulatory requirements and alternative choices require managers to consider risk return trade off, Measurement of risk is costly thus bank managers compromise between precision and cost.

2.5. Empirical Review

Awojobi, Amel and Norouzi (2018) examined factors impacting the efficiency of risk management in Nigerian banks. The study covered a period of 7 years, 2010 – 2016. Cross-sectional data on bank-specific and macro factors were analysed using the panel regression model. The study found out that microeconomic risks such as threats of new competition are unavoidable and must be appropriately dealt with. The study also found out that bank-specific issues such as technological failures, commercial inefficiency of a supplier or customer, political manipulation, are possible risks faced by banks and other financial institutions. These factors impact the efficiency of risk management in Nigerian banks. Growth rate, annual growth rate of inflation and annual growth rate of money supply.

Bhattarai (2016) examined effect of credit risk on Naples commercial banks' performance. A causal-comparative and descriptive research designs was used. The data was obtained from 14 banks for period between the years 2010 – 2015. The study established that NPL loan ratio had adverse effect on performance of banks while the cost of a loan asset had a positive effect on the overall performance of the banks. It was found that indicators of credit risk, size of the bank had a positive impact on the banks' performance. The study established that the ratio of capital adequacy and cash reserve had no influence on bank performance hence a conclusion of a

significant relation between performance of the bank and credit risk indicators. However, this study focused on effect of the credit risk on banks performance and not management of credit risk practices and the financial performance.

Bizuayehu (2016) assessed effect of the management of credit risk on profitability of Ethiopian banks. This study established that, credit risk which is measured by NPL ratio, which indicated a significant inverse impact on financial performance of Ethiopians commercial banks. Chen and Pan (2012) examined the credit efficiency of 34 Taiwanese commercial banks over the period 2005-2008. Their study used financial ratio to assess the credit risk and was analyzed using Data Envelopment Analysis (DEA). The credit risk parameters were credit risk technical efficiency (CR-TE), credit risk allocative efficiency (CR-AE) and credit risk cost efficiency (CR-CE). The results indicated that only one bank is efficient in all types of efficiencies over the evaluated periods. Overall, the DEA results show relatively low average efficiency levels in CR-TE, CR-AE and CR-CE in 2008.

Chiejine (2016) reviewed the regulatory intervention of the Central Bank of Nigeria (CBN) in the operations of some borderline banks in year 2009, which culminated in the sacking of the Board of eight (8) banks and their replacement with new Board members selected by CBN as well as injection of public funds to revive the ailing banks. The study also reviewed the ethical issues surrounding the conduct of the directors and management of the embattled banks within the ambit of the Stakeholder theory and the Caux Round Table Business Principles and arrived at the conclusion that the actions of the Nigerian regulatory authorities were justified.

Dagogo and Ngerebo-a (2018) investigation on loan fraud detection and IT-based combat strategies identified credit risk and loan portfolio mismanagement as the major cause of bank losses. The study was carried out to proffer solutions to the problem escalating non-performing loan being experienced as a result of weak controls and dearth of good decision-making mechanisms in loan disbursement. The study noted that huge portfolio of NPL was responsible for failures of some banks in the past. It contributed to loss of investment by bank shareholders and rendered bank loan inaccessible to the public. The role of information technology in the control environment cannot be overemphasized. It is a critical component for designing and enforcing controls, it also requires effective control dynamics in the areas of input, authorization and access in the process of risk identification, prevention of policy violation, guiding against unauthorized lending and boosting the loan portfolio quality of the banks.

Dogarawa (2018) examined credit process, the canons of lending and methods of loan management in the pre-colonial primitive financial sector, used Kundila, a famous 19th Century trader in Kano City as case study. The study employed the interview and desk research techniques to investigate the impact of lending process and loan management on performance, the study found similarities in both the lending process and loan management system of the pre-colonial era and modern practice.

Research Method

The study employed the ex-post factor research design which entails the utilization of historical data to forecast future trends employing econometric or analytical techniques. The use of ex-post facto design enables researchers to analyses past trends and explain the relationship between the

dependent and independent variables. The population of the study covers 24 reporting commercial banks to Central Bank of Nigeria. However, the sample size covered 13 quoted commercial banks in Nigeria existing within the time scope of this study. Panel data used in the study were collected from annual reports and various databases of the banks for financial statement for the period 2009 to 2018.

2.6. Data Analysis Method

The method of data analysis to be used in this study was the panel data multiple linear regressions using Ordinary Least Square (OLS) method. Moreover, in order to undertake a statistical evaluation of our analytical model, so as to determine the reliability of the results obtained and the coefficient of correlation (r) of the regression, the coefficient of determination (r^2), the student T-test and F-test will be employed.

1. **Coefficient of Determination (r^2) Test** –This measures the explanatory power of the independent variables on the dependent variables. For example, to determine the proportion of economic growth in our model, we used the coefficient of determination. The coefficient of determination varies between 0.0 and 1.0. A coefficient of determination says 0.20 means that 20% of changes in the dependent variable is explained by the independent variable(s).
2. **F-Test:** This measures the overall significance. The extent to which the statistic of the coefficient of determination is statistically significant is measured by the F-test. The F-test can be done using the F-statistic or by the probability estimate. We use the F-statistic estimate for this analysis.
3. **Student T-test:** measures the individual statistical significance of the estimated independent variables at 5% level of significance.
4. **Durbin Watson Statistics:** This measures the colinearity and autocorrelation between the variables in the time series. It is expected that a ratio close to 2.00 is not auto correlated while ratio above 2.00 assumed the presence of autocorrelation.
5. **Regression coefficient:** This measures the extent in which the predictor variables affect the dependent variables in the study.
6. **Probability Ratio:** It measures also the extent in which the predictor variables can explain change to the dependent variables given a percentage level of significant.

3.2. Model Specification

The study adopts the panel data method of data analyses which involve the fixed effect, the random effect and the Hausman Test.

2.7. Pooled Effect Model

$$SSLP_{it} = f(\beta_1 RD + \beta_2 BC + \beta_3 TR + \varepsilon_{it}) \quad (1)$$

2.8. Fixed Effects

The fixed effects focus on whether there are differences by using a fixed intercept for each of the different cross-sectional structures. If we assumed that the dummy variable for a conglomerate company is 1 or 0, then D_i , which is the dummy variable for firm i , can be expressed as:

$$D_i = \begin{cases} 1, & i=1 \\ 0, & \text{otherwise} \end{cases} \quad D_2 = \begin{cases} 1, & i=2 \\ 0, & \text{otherwise} \end{cases} \quad \dots \quad D_N = \begin{cases} 1, & i=N \\ 0, & \text{otherwise} \end{cases} \quad \dots \quad (2)$$

The regression of total samples can be expressed as:¹

$$Y_{it} = \sum_{i=1}^N \beta_{oi} D_i + \beta_1 D_s + \beta_2 D_{ma} + \beta_3 S_1 + \beta_{oi} D_4 S_2 + \varepsilon_{it} \quad \dots \quad (3)$$

The dummy variables are expressed as follows: if $j = i$, then $D_i = 1$; otherwise $D_i = 0$.²

To further investigate the fraud effect, Adebayo (2012) analysed whether the independent variables affect the dependent variable, this regress the effect of the independent variables on the dependent variables.

$$SSLP_{it} = f(\beta_1 RD + \beta_2 BC + \beta_3 TR + \varepsilon_{it}) \quad (4)$$

Because the fixed effects account for both cross-sectional and time-series data, the increased covariance caused by individual-firms differences is eliminated, thereby increasing estimation-result efficiency.

2.9. Random Effects

Random effects focus on the relationship with the study sample as a whole; thus, the samples are randomly selected, as opposed to using the entire population. The total sample regression (a function of the random effect) can be expressed as:

$$SSLP_{it} = \sum_{j=1}^N \beta_0 + f(\beta RD + \beta_2 BC + \beta_3 TR + \varepsilon_{it}) \quad \dots \quad (5)$$

If this is represented with random variables, then $\beta_{oj} = \bar{\beta}_0 + \mu_j$, which indicates that the difference occurs randomly, and the expectation value of β_{oi} is $\bar{\beta}_0$.⁵(6)

Where

SSLP = Sub-standard loan portfolio proxy by log sub- standard classified portfolio

BRD = Bank Risk diversification proxy by log value of sectorial credits

BC = Basel Compliance proxy by risk weight assets to total capital

TR = Risk transfer proxy by log of insurance in deposit insurance corporate

2.10. A-Priori Expectations of the Variables

Model: $BRD_{it} < 0$ $BC_{it} < 0$ and $TR_{it} < 0$

The model had sub-standard loans as the dependent variables; credit risk management is expected to have a negative relationship with sub-standard loans of the commercial banks.

Hausman Test

The Hausman test YairMundlak (1978) is the most commonly used method for evaluating fixed and random effects. If variables are statistically correlated, then the fixed-effects estimation is consistent and efficient, whereas the random- effects estimation is inconsistent, and the fixed-effects model should be adopted. Conversely, if the variables are statistically uncorrelated, then the random-effects estimation is consistent and efficient, whereas the fixed-effects estimation is consistent but inefficient, and the random-effects model should be adopted.

Pooled Regression

In testing pooled regression by using ordinary least squares (OLS) first as it is the simplest to do with panel data. We stipulated that the error term should be independently and normally distributed with zero mean and constant variance and more importantly must not correlated with the independent variables pooled OLS linear regression is given as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \beta_3 X_{4it} + \beta_4 X_{5it} + U_{it} \quad 7$$

Where Y_{it} is the dependent variable; β_0 is a constant term: X_1 , to X_4 , are the independent variables; β_1 to β_4 are slope parameters: $i \dots n$ refer to the cross-sectional units and t is the time period.

Redundant Fixed Effect Test

the study used redundant fixed effect test, also called likelihood ratio test, to test whether the data can simply be pooled and estimated using a standard ordinary least squares regression model or affixed effects panel regression approach can be employed. The fixed effects model is simply a linear regression model in which the intercept terms vary over the individual units' i.e.

$$y_{it} = \alpha_j + x_{it} \beta + \varepsilon_{it} \quad \varepsilon_{it} \approx HD(0, \sigma^2) \quad 8$$

Where it is usually assumed that all x_{it} are independent of all ε_{it} it can write this in the usual regression framework by including a dummy variable for each unit in the model. That is

$$y_{it} = \sum_{j=1}^N \alpha_j d_{ij} + x_{ij} \beta + \varepsilon_{it} \quad \varepsilon_{it} \quad 9$$

Where $d_{ij} = 1$ if $i = j$ and 0 elsewhere. We thus have a set of N . dummy variables in the model. The parameters $\alpha_1, \dots, \alpha_N$ and β can be estimated by ordinary least squares.

The Random Effect Model

It is commonly assumed in regression analysis that all factors that affect the dependent variable, but that have not been included as repressors, can be appropriately summarized by a random error term. In our case, this leads to the assumption that they α_t are random factors, independently and identically distributed over individuals. Thus we write the random effects model as

$$y_{it} = \mu + x_{it}\beta + x_{it}\beta + \alpha_i + \varepsilon_{it} \quad 10$$

Where $\alpha_t + \varepsilon_{it}$ is treated as an error term consisting of two components: an individual specific component, which does not vary over time, and a remainder component, which is assumed to be uncorrelated over time. That is, all correlation of the error terms over time is attributed to the

individual effects α_{it} . It is assumed that α_{it} and ε_{it} are mutually independent and independent of x_{js} (for all i and s). This implies that the OLS estimator for μ and β from (10.15) is unbiased and consistent.

Granger Causality Test

This study tested for causality to examine the relationship between the variables. Although regression analysis deals with the dependence of one variable on other variables, it does not imply causation. Thus, Granger causality test helps in adequate specification of model. In Granger causality, test, the null hypothesis is that no causality between two variables. The null hypotheses is rejected if the probability of F^* statistics given in the Granger causality result is less than 0.05. The pair-wise granger causality test is mathematically expressed as:

$$Y_t \pi_o + \sum_{i=1}^n x_1^y Y_{t-1} \sum_{i=1}^n \pi_1^x x_{t-1} + u_1 \quad 11$$

and

$$x_t dp_o + \sum_{i=1}^n dp_1^y Y_{t-1} \sum_{i=1}^n dp_1^x x_{y-1} + V_1 \quad 12$$

Where x_t and y_t are the variables to be tested while u_t and v_t are the white noise disturbance terms. The null hypothesis $\pi_1^y = dp_1^y = 0$, for all I 's is tested against the alternative hypothesis $\pi_1^x \neq 0$ and $dp_1^y \neq 0$. if the co-efficient of π_1^x are statistically significant but that of dp_1^y are not, then x causes y . If the reverse is true then y causes x . however, where both co-efficient of π_1^x and dp_1^y are significant then causality is bi-directional.

Panel Data Co-Integration Test

A substantial number of these tests are based on testing for a unit root in the residuals of a panel co-integrating regression. The possibility of co- integration between the series from different

alternative estimators is available. With different small and large sample properties (depending upon the type of asymptotic that is chosen).

$$y_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{it} \quad 13$$

Where both y_{it} and x_{it} are integrated of order one. Co-integration implies that ε_{it} is stationary for each i . Homogeneous co-integration. In addition requires that $\beta_i = \beta$ if the co-integrating parameter is heterogeneous. And homogeneity is imposed. One estimate

$$y_{it} = \alpha_i + \beta_i x_{it} + [(\beta_i - \beta)x_{it} + \varepsilon_{it}] \quad 14$$

And in general the composite error term is integrated of order one even if ε_{it} is stationary. However, the problem estimator will also average over i , so that the noise in the equation will be attenuated. In many circumstance, when

Panel Unit Root

We noticed that it is necessary to examine the stationarity of data since the use of non-stationary data can lead to spurious regressions. Unit root tests such as DF test, ADF tests e.t.c, are weak and tend to accept the null hypothesis. Besides, individual unit root tests have limited power. Since we have panel data, Levin, Lin and Chu's (LLC) model is recommended as it allows for both entity-specific and time-specific effects. The null hypothesis is unit root exists, indicating the data is non-stationary. To introduce panel data unit root tests, consider the autoregressive model

$$y_{it} = \alpha_i + \gamma_i y_{it-1} + \varepsilon_{it} \quad 15$$

Which we can rewrite as

$$\Delta y_{it} = \alpha_i + \pi_i y_{it-1} + \varepsilon_{it} \quad 16$$

Where $\pi_i = \gamma_i - 1$. The null hypothesis that all series have a unit root then becomes $H_0 : \pi_i = 0$ for all i . a first choice for the alternative hypothesis is that all series are stationary with the same mean-reversion parameter, that is, $H_1 : \pi_i = \pi < 0$ for each country i , and is used in the approaches of models. The combined test statistics is given by:

$$P = -2 \sum_{i=1}^N \log p_i \quad 17$$

For fixed N , this test statistics will have a Chi-squared distribution with $2N$ degrees of freedom as $T \rightarrow \infty$.

3. Finding and Discussion

Table 1: Presentation of Panel Unit Root Test

Method: Series: SSLP	Statistic	Prob.**	Cross-sections	Obs
Panel unit root at level				
Levin, Lin & Chu t*	-8.30315	0.0000	13	104
Im, Pesaran and Shin W-stat	-3.98841	0.0000	13	104
ADF - Fisher Chi-square	67.2322	0.0000	13	104
PP - Fisher Chi-square	74.1379	0.0000	13	117
Series: TR				
Levin, Lin & Chu t*	-6.06322	0.0000	13	104
Im, Pesaran and Shin W-stat	-2.77278	0.0028	13	104
ADF - Fisher Chi-square	51.9791	0.0018	13	104
PP - Fisher Chi-square	79.2995	0.0000	13	117
Series: BRD				
Levin, Lin & Chu t*	-1.12963	0.1293	13	104
Im, Pesaran and Shin W-stat	0.60320	0.7268	13	104
ADF - Fisher Chi-square	20.2254	0.7808	13	104
PP - Fisher Chi-square	31.5601	0.2081	13	117
Series: BC				
Levin, Lin & Chu t*	-5.51959	0.0000	13	104
Im, Pesaran and Shin W-stat	-3.04147	0.0012	13	104
ADF - Fisher Chi-square	55.4629	0.0007	13	104
PP - Fisher Chi-square	47.7859	0.0057	13	117
Panel unit root at difference				
Series: D(SSLP)				
Levin, Lin & Chu t*	-9.33823	0.0000	13	91
Im, Pesaran and Shin W-stat	-5.39374	0.0000	13	91
ADF - Fisher Chi-square	85.2696	0.0000	13	91
PP - Fisher Chi-square	136.194	0.0000	13	104
Series: D(TR,2)				
Levin, Lin & Chu t*	-8.88220	0.0000	13	78
Im, Pesaran and Shin W-stat	-2.71095	0.0034	13	78
ADF - Fisher Chi-square	53.4071	0.0012	13	78
PP - Fisher Chi-square	137.465	0.0000	13	91
Series: D(BRD)				
Levin, Lin & Chu t*	-16.3128	0.0000	13	91
Im, Pesaran and Shin W-stat	-4.49758	0.0000	13	91
ADF - Fisher Chi-square	71.0321	0.0000	13	91
PP - Fisher Chi-square	111.354	0.0000	13	104
Series: D(BC)				
Levin, Lin & Chu t*	-10.5227	0.0000	13	91
Im, Pesaran and Shin W-stat	-3.83207	0.0001	13	91
ADF - Fisher Chi-square	63.7304	0.0001	13	91
PP - Fisher Chi-square	98.8215	0.0000	13	104

Source: Extract from computation

The Table 1 tests panel unit root on the relationship between bank is diversification, Basel compliance and risk transfer and sub-standard loans portfolio of quoted commercial banks in Nigeria, from the table we can conclude that the results of panel unit root test (IPS test) reported support the hypothesis of a unit root in all variables across among the variables, as well as the hypothesis of zero order integration in first differences. Even at one per cent significance level,

we found that all tests statistics in both with and without trends significantly confirm that all series strongly reject the unit root null at first difference. Given the result of IPS test, it is possible to apply panel cointegration method in order to test for the existence of the stable long-run relation among the variables.

Table 2: Presentation of Multiple Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Fixed regression model				
TR	0.186612	0.212862	0.876683	0.3825
BRD	-0.259741	0.152961	-1.698081	0.0922
BC	0.073548	0.051724	1.421932	0.1578
C	5.246829	0.945947	5.546644	0.0000
Effects Specification				
Cross-section fixed (dummy variables)				
R-squared	0.814227	Mean dependent var		5.037308
Adjusted R-squared	0.789783	S.D. dependent var		1.791149
S.E. of regression	0.821232	Akaike info criterion		2.558796
Sum squared resid	76.88414	Schwarz criterion		2.911723
Log likelihood	-150.3217	Hannan-Quinn criter.		2.702202
F-statistic	33.31005	Durbin-Watson stat		1.236417
Prob(F-statistic)	0.000000			
Random regression model				
TR	0.057245	0.197259	0.290201	0.7721
BRD	-0.268408	0.151829	-1.767837	0.0395
BC	0.066302	0.051259	1.293489	0.1982
C	5.964164	0.938335	6.356114	0.0000
Effects Specification				
			S.D.	Rho
Cross-section random			1.510708	0.7719
Idiosyncratic random			0.821232	0.2281
Weighted Statistics				
R-squared	0.540622	Mean dependent var		0.853414
Adjusted R-squared	0.417780	S.D. dependent var		0.833062
S.E. of regression	0.825623	Sum squared resid		85.88823
F-statistic	4.778365	Durbin-Watson stat		1.092991
Prob(F-statistic)	0.004656			
Unweighted Statistics				
R-squared	0.090198	Mean dependent var		5.037308
Sum squared resid	376.5304	Durbin-Watson stat		0.351121
Correlated Random Effects - Hausman Test				
	Chi-Sq.			
Test Summary	Statistic	Chi-Sq. d.f.		Prob.
Cross-section random	4.350829	3		0.2260

Source: Extract from computation

The Hausman (1978) specification was used to determine the appropriate model on the relationship between credit risk and sub-standard loan portfolio. According to above table shows Hausman specification test the model has the value of $p = 0.2260$, this shows random effect model is more appropriate, because the null hypothesis is accepted. Therefore, this includes insignificant P-value, $\text{Prob} > \chi^2$ larger than 0.05, then it is more suitable to use random effects.

The adjusted R^2 is 0.417780; this implies that 41.7 per cent variations in the sub-sub-standard loans portfolio can be accounted for by the independent variables. This means 58.3 per cent of variations in the sub-standard loan portfolio of the quoted commercial banks are explained by exogenous variable. This also indicates that there are other variables that influence the variations in the level of performing loans. The F-statistics (Fisher statistics which is a measure of the overall goodness of fit of regression) of 4.778365 and probability of 0.004656 which implies that the regression model fitted the data, therefore there is goodness of fit. D-W statistics also showed significant values. The value of the DW statistics which ranges from 0.351121 further indicates that the regression equation is not free from the problem of autocorrelation. Hence, the results cannot be relied upon to make meaningful inferences.

Furthermore, from the random effect results it evidence that bank risk transfer and Basel compliance have positive relationship with sub-standard loan portfolio while risk bank risk diversification have negative relationship with sub-standard loan portfolio of the commercial banks. The estimated model proved that the regression intercept is positive and significant which implies that holding other variables constant, sub-standard loan of the commercial banks increases by 5.96 units.

Table 3. Pedroni Residual Cointegration Test
Series: SSLP TR BRD BC

	<u>Statistic</u>	<u>Prob.</u>	<u>WeightedStatistic</u>	<u>Prob.</u>
Panel v-Statistic	-7.408069	0.0000	-7.922454	0.0000
Panel rho-Statistic	0.740944	0.7706	7.781959	0.0000
Panel PP-Statistic	-7.104736	0.0000	-4.800396	0.0000
Panel ADF-Statistic	-1.476983	0.0698	-1.857446	0.0316
	<u>Statistic</u>	<u>Prob.</u>		
Group rho-Statistic	3.017488	0.0087		
Group PP-Statistic	-7.592356	0.0000		
Group ADF-Statistic	-1.952101	0.0255		

Source: Extract from computation

Since the variables are found to be integrated in the same order $I(1)$, we continue with the panel cointegration tests proposed by Pedroni (1999, 2004). Cointegrations are carried out for constant and constant plus time trend and the summary of the results of cointegrations analyses are presented in table 3. In constant level, we found that the seven statistics reject null hypothesis of no cointegration at the five per cent level of significance for the ADF statistic and group ρ – statistic, while the group –ADF is significant at one per cent level.

Table 4. Pairwise Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Prob.
TR does not Granger Cause SSLP	104	1.97077	0.1448

SSLP does not Granger Cause TR		0.24879	0.7802
BRD does not Granger Cause SSLP	104	3.07297	0.0507
SSLP does not Granger Cause BRD		0.41696	0.6602
BC does not Granger Cause SSLP	104	0.17990	0.8356
SSLP does not Granger Cause BC		0.24925	0.7799

Source: Extract from computation

The objective of the above table was to determine the causal relationship between credit risk and sub-standard loan portfolio of quoted commercial banks. As summarized in table 4. a unidirectional causal relationship has been found between Basel risk compliance and sub-standard loan portfolio indicator of the commercial banks which is significant at 5 per cent probability, because the p-value is < 0.05 . The study found no the causality among the variables.

Evidence from the regression results presented in Table 2 shows that the independent variables can explain 41.7 per cent variation on sub-standard loan portfolio of the commercial banks. This implies that 48.3 per cent can explained by factors not captured in the regression model. The f-statistics and probability indicate that the model is significant and can justify the model. Furthermore, empirical evidence shows that risk transfer and Basel compliance have positive and significant effect on sub-standard loan portfolio of the commercial banks. We expected that credit risk management reduces sub-standard loan portfolio of the commercial banks. Therefore, the positive effect of the variables contradicts our expected results and could be traced to bank lending environment. The positive effect of the variables contradicts the portfolio management theory and risk management theory.

The positive findings of confirm the findings of Nkegbe and Yazidu (2015) whose study reported negative trend in bank performance and a positive relation between market of loan and bank performance, Nyong'o (2014) that credit risk management practices adopted by the banks influences the level of non-performing loans to a great extent and that risk identification, risk monitoring and risk analysis and appraisal would lead to decrease in non-performing loans, the findings contradict the findings of Olawale (2014) whose findings showed negative relationship but not significant between loan ratio and total advances in terms of deposits and further shown a significant negative relationship between nonperforming loans and advances rate and banks' profitability.

However, the estimated regression model found that bank risk diversification has negative and significant relationship with sub-standards loan portfolio of the commercial banks. The regression coefficient justifies that bank risk diversification will reduce sub-standard loan portfolio of the commercial banks by 0.26 percent. The negative effect of bank risk diversification on substandard loan portfolio of the commercial banks confirms the a-priori expectations of the study and confirms the relevance of risk diversification. The findings further confirm the modern portfolio theory. The negative findings of confirm the findings of Nkegbe and Yazidu (2015) whose study reported negative trend in bank performance and a positive relation between market of loan and bank performance, Nyong'o (2014) that credit risk management practices adopted by the banks influences the level of non-performing loans to a great extent and that risk identification, risk monitoring and risk analysis and appraisal would

lead to decrease in non-performing loans, the findings contradict the findings of Olawale (2014) whose findings showed negative relationship but not significant between loan ratio and total advances in terms of deposits and further shown a significant negative relationship between nonperforming loans and advances rate and banks' profitability.

4. Conclusion

This study examined the effect of credit risk management on the sub-standard loans of commercial banks in Nigeria. The empirical results proved that 41.7 per cent variations in the sub-sub-standard loans' portfolio can be accounted for by the independent variables while 58.3 per cent of variations in the sub-standard loan portfolio of the quoted commercial banks are explained by exogenous variable. Furthermore, from the random effect results, bank risk transfer and Basel compliance have positive relationship with sub-standard loan portfolio while risk bank risk diversification have negative relationship with sub-standard loan portfolio of the commercial banks.

1. The management of the commercial banks should be pro-active and devise effective measures of managing credit risk to reduce the incidence of sub-standard loans. The monetary authority should monitor the Basel compliance rate and policies of the commercial banks to credit risk management.
2. There should be an effective credit risk management department of every commercial bank to enhance effective asset management that will reduce the incidence of sub-standard loans.
3. Loan product diversification across different sectors and products has beneficial effects on the credit risk management. Commercial banks in Nigeria should put more emphasis on risk management and credit worthiness analysis, credit score analysis and internal ratings in their credit risk management practices. Risk diversification is one major way of effective credit risk management; therefore, management should enhance risk diversification policies.

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Description of Colombian Electricity Pricing Derivatives

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Abstracts

Electricity markets are becoming a popular field of research amongst academics because of the lack of appropriate models for describing electricity price behavior and pricing derivatives instruments. Models for price dynamics must consider seasonality and spiky behavior of jumps which seem hard to model by standard jump process. Without good models for electricity price dynamics, it is difficult to think about good models for futures, forward, swaps and option pricing. In this paper we attempt to introduce an algorithm for pricing derivatives to intuition from Colombian electricity market. The main ambition of this study is fourfold: 1) First we begin our approach through to simple stochastic models. for electricity pricing. 2) Next, we derive analytical formulas for prices of electricity derivatives with different derivatives tools. 3) Then we extent short of the model for price risk in the electricity spot market 4) finally we construct the model estimation under the physical measures for Colombian electricity market. And this paper end with conclusion.

Key Words - Electricity markets, Energy Derivative, Option and Forward Contract.

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1. Introduction

Deregulation of electricity markets has led to a considerable increase in risk accepted by market participants. The often unexpected, extreme spot price changes range even two orders of greatness and can cause severe financial problems to the efficacies that buy electricity in the wholesale market and deliver it to consumers at fixed prices. The utilities and other power market companies essential to hedge against this price risk. A forthright way to do it is to use derivatives, like forwards and options.

Here, we use the latter approach and describe the spot price dynamic models to review the electricity pricing with details of how to implement the pricing of electricity market a After specifying a model we must choose for derivatives pricing methodology. However, such approach fails in case of electricity due to extremely limited storage possibilities.

Therefore, instead of using a discrete time model approach we employ a concept of the risk premium / market price of risk and find such pricing measure that yields the observed forward market prices. With such methodology we can originate forward prices from the spot price model and to find unambiguous formulas for premiums of European options written on spot, as well as, on forward prices.

Over the last two eras the electricity manufacturing worldwide has undergone a profound restructuring process. Particularly in Colombia, laws 142 and 143 of 1994 in addition to later reforms, opened an concentrated reorganization of the electricity market, like the creation of the wholesale electricity market (MEM) in 1995 instantaneously to the vertical unbundling of the generation, transmission, distribution, and retail activities, seeking to expand the efficiency and worth of the electricity industry. Under this new framework, the power generation and retail businesses could be competitive deregulated markets, whereas the remaining two, transmission and distribution, were recognized as regulated activities.

Colombia has a hydro-dominated electricity market. Roughly 80% of its energy comes from hydro resources, 67% of its capacity, and 50% of its firm energy—energy in an exceptionally dry period. The keystones of the wholesale electricity market in Colombia are the spot energy market and the firm energy market. The spot energy market is a single-zone hourly market that regulates the spot energy price in every hour as well as the efficient dispatch of resources.

The aim of this paper is to introduce pricing electricity derivatives to the Colombian market with an alternative formalism.

1. Stochastic Model for Electricity Pricing Derivatives.

In the past few years there has been a quickly cumulative literature on stochastic models for prices of electricity and other commodities. Many researchers have experimental that the models typically used in financial markets are unsuitable due to the special features of commodity prices and especially of electricity prices as described in the introduction.

In this section we will give a short estimate of some of the models considered so far in the literature and comparison them with our approach.

The special of stochastic model for electricity prices differs on the time coarseness that needs to be replicated in the model. Liquidly import/export futures and forward contracts classically have full months, quarters, or years as delivery periods, either as base load or peak load. Price estimates for single hour deliveries are in most cases only available as day-ahead prices from the spot market. However, many structured Over The Market (OTC) products, such as swing options, are strongly influenced by the hourly price behavior. Since due to the non-storage stability of electricity, spot products cannot be used for hedging

purposes, the electricity market is a highly incomplete market and pure arbitrage option pricing methods fail for most structured products.

Previous work has been focused mainly on either of the two following approaches:

- Market models for futures prices: As an alternative of modeling the spot price and deriving futures prices, the futures prices themselves are demonstrated. This method goes back to Black's model (1976), where a single futures contract is measured. Ideas from the Heath – Jarrow - Morton theory for interest rates Heath, Jarrow, and Morton (1992) are used in Clewlow and Strickland (1999), Box and Jenkins (1976), Koekebakker and Ollmar (2001) and Manoliu and Tompaidis (2002) to model the dynamics of the complete futures price curve. Such models have the benefit that the market can be considered as being complete and standard risk-neutral pricing may be used. Risk-neutral parameters can often be roundabout from traded options on futures prices. The weakness of such approaches is that futures prices do not expose the information about price behavior on an hourly or even daily time scale.
- Spot price models: This model aims at apprehending the hourly price behavior by fitting their model to historical spot price data. Since there is no arbitrage kith and kin between spot prices and futures prices, in additional conventions must be made to use this model for pricing derivatives. Generally, this is done either by assuming the balanced expectation hypothesis

$$F_{t,T} = E[S_T | F_t], \quad (1)$$

As done e.g. in Tseng and Barz (2002) to price generation assets, or by standardizing a market price of risk for each factor and then the altering to an equivalent martingale measure P^* under which the relation $F_{t,T} = E^*[S_T | F_t]$, holds.

Maximum, the models for the spot market engagement at least two risk factors: first one, seizing the short-term hourly price dynamics characterized by mean reversion and tremendously high volatility, and the other factor demonstrating long-term price behavior observed in the futures market. Since there are no liquidly traded derivatives on a daily or hourly time gauge that have a strong dependence on the short-term risk factor, it is exceptionally difficult to guesstimate the short-term market price of risk.

Through this paper we will denote S_t the spot market price at time t . Since are working in a predetermined interest rate framework, we will not differentiate between forward and futures prices. Therefore, single hour futures prices at time t for delivery at time T are

conditional opportunities under the equivalent martingale measure

$$F_{t,T} = E^*[S_T | F_t], \quad (2)$$

Where $F_t = \sigma[S_s : s \leq t]$, is the natural filtration produced by the prices process.

Future prices for power delivery over a period $S_t = () [T_1, T_2]$ are given by

$$F_{t,T_1,T_2} = E^* \left[\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} S_T dT | F_t \right] = \frac{1}{T_2 - T_1} \int_{T_1}^{T_2} F_{t,T} dT, \quad (3)$$

Or, in a discrete time setting by

$$F_{t,T_1,T_2} = E^* \left[\frac{1}{T_2 - T_1} \sum_{T=T_1}^{T_2-1} S_T \middle| F_t \right] = \frac{1}{T_2 - T_1} \sum_{T=T_1}^{T_2-1} F_{t,T}. \quad (4)$$

The simplest model considering mean-reverting behavior is given by an Ornstein-Uhlenbeck process. Here the price process S_t is a diffusion process satisfying the stochastic differential equation

$$dS_t = -(\lambda(S_t - a))dt + \sigma dW_t, \quad (5)$$

Where (W_t) is a standard Brownian motion, σ the volatility of the development, and λ the velocity with which the process reverts to its long term mean a .

In electricity markets prices show powerfully mean reverting behavior so that estimations for λ are quite large. Representative characteristic times for mean reversion are within a few days. Therefore, this model has the main disadvantage that futures prices are nearly constant over time, since under the assumption of Koekebakker and Ollmar (2001) the futures price is given by

$$F_{t,T} = a(1 - e^{-\lambda(T-t)}) + S_t e^{-\lambda(T-t)} \quad (6)$$

For this motive, several authors proposed a two-factor model, see e.g. Gibson and Schwartz (1990), Pilipovic (1988) and Schwartz and Smith (2000). In Pilipovic (1988) a model of the form

$$dS_t = -\lambda(S_t - Y_t)dt + \sigma dW_t \quad (7)$$

is suggested, where Y_t is a Brownian motion. A parallel model is given in Schwartz and Smith (2000), where commodity prices are designated in the form

$$S_t = \exp(X_t + Y_t), \quad (8)$$

where (X_t) is an Ornstein - Uhlenbeck process accountable for the short-term variation and (Y_t) is a Brownian motion recitation the long-term dynamics. From this model, we will present in and can be considered as an extension of the ideas of Schwartz and Smith (2000). All models are measured so far did not contemplate seasonality. Some authors purely abandonment this serious difficulty. Others propose to use deterministic seasonality designated by sinusoidal functions, see Barlow (2002), Elliott, Sick, and Stein (2003), Geman, and Roncoroni (2003), and Schwartz and Smith (2000). In Knittel and Roberts (2001) it is suggested to use equation (5) with a long run mean a_t describing the seasonal patterns. A general deterministic seasonality is proposed in Knittel and Roberts (2001) and Gibson and Schwartz (1990). Here, the spot price is modeled as

$$S_t = f(t) + X_t \text{ or } S_t = \exp(f(t) + X_t) \quad (9)$$

with an arbitrary deterministic function $f(t)$ and a mean-reverting stochastic process X_t

In our approach, the deterministic component $f(t)$ is specified by the load forecast $\hat{t}$ and additional stochastic behavior is introduced using SARIMA models for the time series of load and prices.

Many authors are attempted different way to account for price spikes. One possibility to manage with spikes is the overview of jump terms, see Box and Jenkins (1976), Knittel and Roberts (2001) and Heath, Jarrow, and Morton (1992). The main disparagement for these models is that under the typical assumption of a jump-diffusion model a huge upward jump is not necessarily tailed by a great downward jump. Therefore, some authors suggest hidden Markov models, known as Markovian regime-switching models, where it is defined that upward jumps are tracked by downward jumps. Such models have been reflected e. g. in De Jong, and Huisman (2002), Deng (2000), Elliott, Sick, and Stein (2003), Huisman, and Mahieu (2001) and Kholodnyi (2000). Regime-switching models are very instinctive candidates for electricity price models since there are some clear physical reasons for switches of regimes such as forced outages of significant power plants. On the other hand, it gives the impression to be problematic to combine regime-switching with seasonality.

In Additional, another approach is interested by the economic background for price spikes. Prices are originated mainly by supply and demand (load). Therefore, the non-linear relation between load and price should be considered in the model. This non-linear renovation is called the 'power stack function' in Eydeland, and Geman (1999) and Skantze, Gubina, and Ilic, (2000). They recommend an exponential function for that determination. A similar model for spot prices has recently been measured in Black (1976), where the relation

$$S_t = f(X_t) \quad (10)$$

is suggested with X_t being an Ornstein- Uhlenbeck process, and f a power function. We also choose an method based on the power stack function, since there is a natural understanding of this non-linear transform in terms of the merit order curve.

2. Electricity Derivatives Pricing

Electricity options

The power industry had been exploiting the idea of options through surrounded terms and conditions in many supplies and obtaining contracts for decades, deprived of obviously recognizing and valuing the options until the commencement of the electricity industry rearrangement in the U.K., the U.S., and the Nordic countries in the 1990s. The development of the electricity wholesale markets, and the dissemination of option pricing and risk management techniques have shaped electricity options not only based on the underlying price attribute (with plain vanilla electricity call and put options), but also other attributes like volume, delivery location and timing, quality, and fuel type.

Fundamentally, a counterparty of each financial option can be shaped in the domain of electricity options and by substituting the underlying in a financial option with electricity market Hull (2000) for introduction to various kinds of financial options (American Style, European Style, Exchange Traded Options, Over the Counter Options, Option Type by Underlying Security and Option Type by Expiration). At this point, we entitle a sample of electricity options that are frequently utilized in risk management applications in generation and distribution sectors. These options are generally had short- to medium maturity times such as months or a couple of years. Options with maturity times longer than three years are usually entrenched in long-term supply or purchase contracts, which are termed as organized transactions.

Now, we turn to pricing of a European call option written on the electricity spot price. Recall, that the European option is a contract that gives the buyer the right to buy/sell the underlying commodity at some future date t (called maturity) at a certain price K (called the strike price). First, we find the pricing measure Q^λ . Like Merton (1976) in the context of jump-diffusion processes we assume that the dynamics of spikes and drops are the same in the actual and pricing measures. We start with finding the spot price dynamics under λ parameterization.

Let $\lambda(u)$ be a deterministic function square-integrable on $u \in [0, T_{\max}]$, where $T_{\max}$ is a time horizon long enough to contain all maturities of derivatives quoted in the market, and introduce a new process W_t^λ :

$$W_t^\lambda = W_t + \int_0^t \frac{\lambda(u)}{\sigma_b} du, \quad (11)$$

where σ_b is the volatility of the base regime. From the Girsanov theorem we have that W_t^λ is a Wiener process under a new measure Q^λ defined as

$$\frac{dQ^\lambda}{dQ} = \exp \left[- \int_0^{T_{\max}} \frac{\lambda(u)}{\sigma_b} dW_u - \frac{1}{2} \int_0^{T_{\max}} \left(\frac{\lambda(u)}{\sigma_b} \right)^2 du \right] \quad (12)$$

with the filtration F_t^W , being the natural filtration of the process W_t .

Now, the base regime process $X_{t,b}$ can be rewritten as:

$$dX_{t,b} = [\alpha - \lambda(t) - \beta X_{t,b}] dt + \sigma_b dW_t^\lambda \quad (13)$$

and the expected future spot price is given by:

$$E^\lambda(P_t | F_0) = p_{bb}^{(t)} \left[X_0 e^{-\beta t} + \frac{\alpha}{\beta} (1 - e^{-\beta t}) - \int_0^t e^{-\beta(t-u)} \lambda(u) du \right] + p_{bs}^{(t)} \left(e^{\mu_s + \frac{1}{2} \sigma_s^2} + c_s \right) + p_{bd}^{(t)} \left(-e^{\mu_d + \frac{1}{2} \sigma_d^2} + c_d \right) + g_t. \quad (14)$$

The function $\lambda(t)$ can be calibrated to the market forward prices so that $E^\lambda(P_t | F_0) = f_0^t$, e.g. by using some fitting procedure (like the least squares minimization). Alternatively, one can find the risk premium and then use the relation between the market price of risk $\lambda(t)$ and the risk premium:

$$p_{bb}^{(t)} \int_0^t e^{-\beta(t-u)} \lambda(u) du = RP(t), \quad (15)$$

which is a simple consequence of the fact that $RP(t) = E(P_t | F_0) - E^{\lambda}(P_t | F_0)$, formula (15) and Ito's lemma.

Now, the price of a European call option written on the electricity spot price can be derived.

Option price formula. If the electricity spot price P_t is given by the MRS model then the price of a European call option written on P_t with strike price K and maturity T is equal to:

$$C_T(K) = e^{-rT} [p_{bb}^{(T)} C_{T,b}(K) + p_{bs}^{(T)} C_{T,s}(K) + p_{bd}^{(T)} C_{T,d}(K)], \quad (16)$$

where

$$C_{T,b}(K) = \frac{s}{\sqrt{2\pi}} \exp\left(-\frac{(K'-m)^2}{2s^2}\right) + (m-K') \left[1 - \Phi\left(\frac{K'-m}{s}\right)\right], \quad (17)$$

$$C_{T,s}(K) = \Pi_{\{K' > c_s\}} \left\{ \exp\left(\mu_s + \frac{\sigma_s^2}{2}\right) \left[1 - \Phi\left(\frac{\log(K'-c_s) - \mu_s - \sigma_s^2}{\sigma_s}\right)\right] - (K'-c_s) \left[1 - F_{LN(\mu_s, \sigma_s^2)}(K'-c_s)\right] \right\} \\ + \Pi_{\{K' \leq c_s\}} \left\{ \exp\left(\mu_s + \frac{\sigma_s^2}{2}\right) + c_s - K' \right\} \quad (18)$$

and

$$C_{T,d}(K) = \Pi_{\{K' < c_d\}} \left\{ -\exp\left(\mu_d + \frac{\sigma_d^2}{2}\right) \Phi\left[\frac{\log(c_d - K') - \mu_d - \sigma_d^2}{\sigma_d}\right] + (c_d - K') F_{LN(\mu_d, \sigma_d^2)}(c_d - K') \right\} \quad (19)$$

Further, $K' = K - g_T$, $m = X_0 e^{-\beta T} + \frac{\alpha}{\beta} (1 - e^{-\beta T}) - \int_0^T e^{-\beta(T-u)} \lambda(u) du$, $s^2 = \frac{\sigma_b^2}{2\beta} (1 - e^{-2\beta T})$ and

$F_{LN(\mu, \sigma^2)}$ is the cumulative distribution function of the log-normal distribution with parameters μ and σ^2 .

Here, we assume that the option is settled in an infinitesimal period $[T, T + \Delta]$. However, in practice, the electricity spot price usually corresponds to a delivery during some period (e.g. an hour, a day) and, hence, the maturity of the option should be specified on the same timescale. On the other hand, the examined spot price quotations usually represent some delivery period. For example, if the measured data is quoted daily, then the maturity of the option would be also given in daily timescale and would correspond to daily delivery.

Electricity Forwards

An Electricity forward contract is a customized contract between two parties to buy or sell an asset at a specified price on a future date. A forward contract can be used for hedging or speculation, although its non-standardized nature makes it particularly apt for hedging. Electricity forward contracts characterize the obligation to buy or sell a fixed amount of electricity at a pre-specified agreed price, known as the forward price, at specific time in the future (called maturity or expiration time). In other words, electricity forwards are convention tailored supply contracts between a buyer and a seller, where the buyer is obligated to take power and the seller is obligated to supply. The payoff of a forward contract auspicious to deliver one unit of electricity at price F at a future time T is:

$$\text{Payoff of a Forward Contract} = (S_T - F)$$

Where S_T is the electricity spot price at time T . Although the payoff function (1) appears to be the same as for any financial forwards, electricity forwards differ from other financial and commodity forward contracts in that the underlying electricity is a different commodity at different times. The settlement price S_T is usually calculated based on the average price of electricity over the delivery period at the maturity time T .

Undoubtedly, the most popular electricity derivatives are the forward contracts. Recall that a forward contract is an agreement to buy (sell) a with specific amount of the underlying (here MWh of electricity) at a specified forward date. Settlement of the contract can be specified with physical delivery of electricity or with only financial clearing. Both types of settlement are in the following called delivery date. Denote the price at time t of a forward contract with a delivery at time T by f_t^T . There is no investment at the of entering a forward contract, the expected future payoff under the pricing measure should fulfill:

$$E^\lambda(P_T - f_t^T | F_t) = 0, \quad (20)$$

what implies that

$$f_t^T = E^\lambda(P_T | F_t). \quad (21)$$

Observe, that now we define the price of a forward contract at any future date t . This is motivation by the circumstance that the valuation at time 0 of an option written on a forward contract requires the knowledge about the forward price dynamics at the option's maturity t

Forward price formula. If the electricity spot price P_t is given by the MRS model, then the price at time t of a forward contract written on P_t with a delivery at time T is given by the following formula

$$f_t^T = P(R_{[T]} = b | F_t) \left[E^\lambda(X_{t,b} | F_t) e^{-\beta(T-t)} + \frac{\alpha}{\beta} (1 - e^{-\beta(T-t)}) - \int_t^T e^{-\beta(T-u)} \lambda(u) du \right] +$$

$$P(R_{[T]} = s | F_t) \left(e^{\mu_s + \frac{1}{2}\sigma_s^2} + c_s \right) + P(R_{[T]} = d | F_t) \left(c_d - e^{\mu_d + \frac{1}{2}\sigma_d^2} \right) + gt, \quad (22)$$

where $P(R_{[T]} = i | F_t) = \sum_{j \in \{b,s,d\}} P(R_{[T]} = i | R_{[t]} = j) \mathbf{1}_{\{R_{[t]} = j\}}$.

Note that in the above formula $E^\lambda(X_{t,b} | F_t)$ is used, since this expectation depends on the state process value at time t . Namely, if $R_t = b$ then $E^\lambda(X_{t,b} | F_t) = X_{t,b} = X_t$. On the other hand, if at time t a spike or a drop occurred then $E^\lambda(X_{t,b} | F_t) = E^\lambda(X_{t,b} | F_{t-1})$ and again this expectation is dependent on R_{t-1} value.

When deriving the forward price dynamics, we must remember that the belongings of the obtained model should observe with the observed market prices. One of the most pronounced features of the market forward prices is the detected term structure of volatility, called the Samuelson effect. Exactly, the volatility of the forward prices is moderately low for distant delivery periods, however, it increases quickly with impending maturity of the contracts.

Here, the forward price volatility is described by the part $P(R_{[T]} = b | F_t) E^\lambda(X_{t,b} | F_t) e^{-\beta(T-t)}$ of formula (22). Hence, it is specified by the volatility of the spot price base regime scaled with $e^{-\beta(T-t)}$ and the corresponding probability of switching to the base regime. Observe that the scaling factor $e^{-\beta(T-t)}$ exhibits the Samuelson effect as it increases to 1 with t approaching maturity time T . Moreover, the forward price volatility, again due to the scaling factor, is lower than the spot price volatility. This is following the behavior of the market spot and forward prices.

Electricity forward contracts listed on energy exchanges are usually settled during a certain period (a week, a month, a year, etc.). Denote the price at time t of a forward contract

settled during the period $[T_1, T_2]$ by $f_t^{[T_1, T_2]}$. Obviously, the latter is the mean price of forward contracts with delivery during the period $[T_1, T_2]$, namely:

$$f_t^{[T_1, T_2]} = \int_{T_1}^{T_2} w(T_1, T_2, T) f_t^T dT = \int_{T_1}^{T_2} w(T_1, T_2, T) E^\lambda(P_T | F_t) dT, \quad (23)$$

where $w(T_1, T_2, T)$ is the weight function representing the time value of money. The form of w depends on the contract specification. For contracts settled at maturity we have

$$w(T_1, T_2, T) = \frac{1}{T_1 - T_2}, \text{ while for instant settlement } w(T_1, T_2, T) = \frac{re^{-rT}}{e^{-rT_1} - e^{-rT_2}}, \text{ where } r > 0 \text{ is}$$

the interest rate (Benth et al., 2008a). The price $f_t^{[T_1, T_2]}$ can be obtained from formulas (3.10) and (3.11). Indeed, we have:

$$\begin{aligned} f_t^{[T_1, T_2]} &= E^\lambda(X_{t,b} | F_t) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | F_t) e^{-\beta(T-t)} dt + \\ &\int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | F_t) \left[\frac{\alpha}{\beta} (1 - e^{-\beta(T-t)}) - \int_t^T e^{-\beta(T-u)} \lambda(u) du \right] dT + \\ &\left(e^{\mu_s + \frac{1}{2}\sigma_s^2} + c_s \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = s | F_t) dT + \\ &\left(c_d - e^{\mu_d + \frac{1}{2}\sigma_d^2} \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = d | F_t) dT + \int_{T_1}^{T_2} w(T_1, T_2, T) g_T dT \end{aligned} \quad (24)$$

OPTIONS WRITTEN ON ELECTRICITY FORWARD CONTRACTS

Lastly, we derive an unambiguous formula for a European call option written on a forward contract delivering electricity during a specified period. Observe, that the forward price $f_t^{[T_1, T_2]}$ depends on the spot price at time t and, consequently, also on the state process value at time t .

Now, we will consider an option written on an electricity forward contract with settlement during a specified period, as it is the most popular specification of electricity options on energy exchanges. For example, in the European Energy Exchange (EEX) market there are options written on forward contracts with monthly, quarterly, and yearly settlement periods. The maturity of such options is set to the quarter business day before the beginning of the underlying contract's settlement period.

Price formula for an option written on a forward contract. The price of a European call option with strike price K and maturity t written on a forward contract with delivery during the period $[T_1, T_2]$ is equal to:

$$C_t^{[T_1, T_2]}(K) = e^{-rt} \left\{ A_0(b) C_{t,b} \left(\frac{K - B_0(b)}{A_0(b)} + g_t \right) P(R_{[t]} = b | R_0 = b) + \sum_{i \in \{s,d\}} \sum_{k=1}^{[t]} \left[A_k(i) C_{[t]-k+1,b} \left(\frac{K - B_k(i)}{A_k(i)} + g_{[t]-k+1} \right) \times P(R_{[t]} = i, R_{[t]-1} \neq b, \dots, R_{[t]-k} = b | R_0 = b) \right] \right\} \quad (24)$$

Where $A_k(i) = \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | R_{[t]} = i) e^{-\beta(T-[t]+k-1)} dT, \quad (25)$

$$A_0(b) = \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | R_{[t]} = b) e^{-\beta(T-t)} dT, \quad (25)$$

$$B_k(i) = \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | R_{[t]} = i) \times \left[\frac{\alpha}{\beta} (1 - e^{-\beta(T-[t]+k-1)}) - \int_{[t]-k+1}^T e^{-\beta(T-u)} \lambda(u) du \right] dT + \left(e^{\frac{\mu_s + \frac{1}{2}\sigma_s^2}{2}} + c_s \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = s | R_{[t]} = i) dT + \left(c_d - e^{\frac{\mu_d + \frac{1}{2}\sigma_d^2}{2}} \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = s | R_{[t]} = i) dT + \int_{T_1}^{T_2} w(T_1, T_2, T) g_T dT \quad (26)$$

$$B_0(b) = \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = b | R_{[t]} = b) \left[\frac{\alpha}{\beta} (1 - e^{-\beta(T-t)}) - \int_t^T \frac{\alpha}{\beta} (e^{-\beta(T-u)} \lambda(u) du) \right] dT + \left(e^{\frac{\mu_s + \frac{1}{2}\sigma_s^2}{2}} + c_s \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = s | R_{[t]} = b) dT + \left(c_d - e^{\frac{\mu_d + \frac{1}{2}\sigma_d^2}{2}} \right) \int_{T_1}^{T_2} w(T_1, T_2, T) P(R_{[T]} = d | R_{[t]} = b) dT + \int_{T_1}^{T_2} w(T_1, T_2, T) g_T dT \quad (27)$$

And $C_{t,b}(K)$ is the “base regime part” of the price of a European call option written on the electricity spot price with maturity t and strike K , see equation (3.7) with $T = t$.

3. MODEL FOR PRICE RISK

Electricity have proven to be the most volatile commodity, and it is not the exception in the

Colombian competitive electricity market. It makes it compulsory to develop an appropriate risk management to maximize agents' benefits and minimize the corresponding uncertainty upon them. Among the risks that firms must handle with, are macroeconomic risk, price risk, market risk, credit risk, regulatory risk, country risk, and quantity risk. The last one is a non- tradable risk, and an implicit feature of electricity, which has to do with the amount of energy that will be demanded in the future, which follows a stochastic process as well as the spot price. This situation directly impacts the firm's revenues and makes it necessary to include it when designing the hedging portfolio.

Here, we developed a financial theory for research studies to find how to address this problem. In Liu, and Wu (2007) electricity risk management is handled by a multi-market trading approach, while other references like Huisman, Mahieu, and Schlichter (nd) get emphasis on best risk management through forward on-peak and off-peak contracts. Nevertheless, the electricity derivatives are progressively studied and used around the world to manage the financial risks and resource appropriateness of power markets, like it is advocated in Chao, and Wilson (nd). Particularly Villareal, and Soto (nd) proposed a financial call option to hedge against critical hydrologic scenarios in the Colombian electricity system by ensuring generation adequacy.

Further, derivative instruments have been developed to also handle the quantity risk, like swing options, weather derivatives, interruptible contracts, among other instruments named in Deng, and Oren(2006). The features of these derivative products make them be usually traded over the counter (OTC); therefore, they are low liquidity instruments, which is why they are not regarded in this paper. However, references Oum, Oren, and Deng (2006) and Prokopczuk, Rachev, Schindlmayr, and Truck,(nd) study quantity risk.

Oum, Y., Oren, S. (nd) deal with the static hedging problem of a LSE who has to serve an uncertain electricity demand q at a regulated fixed price r in a single period from 0 to 1. Besides, the LSE procures the electricity to serve his customers, from the wholesale market at a spot price p . Hence the profit of the LSE would be:

$$y(p, q) = (r - p) \cdot q \quad (28) s$$

To protect himself against price risk, the LSE can take a long position in q^{-9} forward contracts at a fixed forward price F . However, the LSE will face another risk that arises

from the fact that demand $\bar{q}$ may vary from the expected value at time 0 to the actually realized value at time 1. Then, if the actual demand realized by the retailer agent is $\bar{q} + \Delta q$, then, the share of the profit in Chao and Wilson (nd), that is at risk is: $(r - p) \cdot \Delta q$, where Δq could be different to zero (gains/losses).

To deal with this hedging problem, the authors derive the optimal hedging portfolio as a function of spot price p . That is:

$$Y(p, q) = (r - p)q + x(p) \quad (29)$$

where $x(p)$ is the optimal hedging portfolio as function of the spot price p .

Regarding the LSE's preferences and risk aversion profile, it is necessary to identify its utility function U over total profit Y . In turn, because of the positive correlation between price and demand, which will be evident later in the paper for the Colombian electricity market, there exists a joint probability function $f(p, q)$ defined on the probability measure P , which characterizes the behavior of p and q at time 1. On the other side, Q is a risk-neutral probability measure by which the hedging instruments are priced and $g(p)$ is the probability density function of p under Q . Keeping this in mind, in the optimization problem is formulated as follows:

$$\max_{x(p)} E[U(Y(p, q))] \quad (30)$$

$$\text{s.t. } E^Q[x(p)] = 0 \quad (31)$$

where $E[\cdot]$ and $E^Q[\cdot]$ denote expectations under probability measures P and Q , respectively. In (30) the constraint implies that the hedge portfolio $x(p)$ is self-financing, that is, the LSE can borrow funds in the money market, in order to purchase the derivative instruments needed to obtain the maximum expected utility over the total profit $Y(p, q)$. This constraint also means that there are not arbitrage opportunities through this hedging portfolio, under a constant risk-free rate. The optimization process yields as a result the optimal payoff function $x^*(p)$.

Through an extension of the fundamental calculus theorem, it is demonstrated that any twice continuously differentiable function can be written as follows, for fixed value F :

$$x(p) = x(F) \cdot 1 + x'(F) \cdot (p - F) + \int_0^F x''(K) \cdot (K - p)^+ dK + \int_F^\infty x''(K) \cdot (p - K)^+ dK \quad (32)$$

The expression $(\cdot)^+$ in the above equation, is equivalent to the function $\max(\cdot, 0)$. It is important to note that in the expressions above 1, $(p - f)$, $\max(K - p, 0)$, $\max(p - K, 0)$ correspond to the payoff profile of a bond, forward contract, put option and call option, respectively. In this sense, and remaining the LEGO© approach theory presented, with $x(F)$ units in bonds, $x'(F)$ units of forward contracts, $x''(K)dK$ units of put options with strike price $K(K < F)$ and $x''(K)dK$ units of call options with strike price $K'(K' > F)$, it is possible to replicate the resultant optimal hedging portfolio $x^*(p)$ from the optimization process. This financial derivative have as underlying asset the electricity spot price.

Viewed from this angle, to replicate the optimal function $x^*(p)$, the equation (32) implies that it is necessary to have a set of continuum strike prices for both put and call options. Since markets are incomplete, there are no markets with that amount of strike prices on board, and assuming that there is only n put options and m call options available in the market, Oum, Deng and Orend proposed a portfolio compounded by $x(F)$ units of bonds, $x'(F)$ units of forward contracts, $\frac{1}{2}(x'(K_{i+1}) - x'(K_{i-1}))$ units of put options with strike prices $K_i, i = 1, \dots, n$. and $\frac{1}{2}(x'(K_{j+1}) - x'(K_{j-1}))$ units of call options with strike prices $K_j, i = 1, \dots, m$.

The errors of this replicating strategy are calculated depending on the range in which spot price is realized at time 1.

4. MODEL ESTIMATION UNDER THE PHYSICAL MEASURE

The non-storability feature of electricity along with the steeply rising supply and the inelastic demand curve, both schematically represented in Figure 1, makes the electricity price p and the electricity demand q to be positive correlated. It happens in this way in the Colombian electricity market, since the dispatch is carried out in order of merit, so, when demand rises during on-peak hours, it forces the system to put in operation a more expensive generation resource, increasing the spot price as well.

Additional to the fact explained above, throughout summer seasons, the hydropower plants which are technologies with lower variable costs, reduce their power production due to natural water inflows shortages and of course to a diminishment in water reserves into reservoirs. This turns out in a higher marginal system cost, so an increment in demand translates into an increase in the spot price. This increment in the spot price reaches larger values during summer seasons than during winter seasons. Therefore, the correlation

between p and q is bigger during dry periods in the Colombian wholesale electricity market.

The earlier reasons justify the usage of the price-quantity hedging strategy presented, to design suitable derivative instruments to be used by the agents of the electricity market.

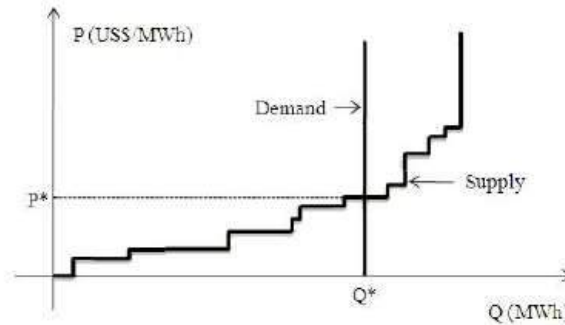


Figure 1: Supply and demand equilibria at Colombian electricity market.

The advantage offered by the financial derivative products, arises from the fact that is likely to achieve the maximum expected value of total profit $Y(p, q)$, together with the minimum deviation of this profit (which means less uncertainty over LSE's total profit), after building a hedging portfolio with those instruments. To do so, a utility function to represent the risk aversion preferences of the agents like a mean-variance utility function is a good candidate to accomplish both goals at the same time. Here it is utilized the same mean-variance utility function which has been used in financial hedging literature to deal with non-tradable risk:

$$U(Y) = Y - \frac{1}{2} a (Y^2 - E[Y]^2) \quad (33)$$

where a represents the agent's risk aversion coefficient. Certainly, maximizing the expected value of the utility function in (33) $\left(E[U(Y)] = E[Y] - \frac{1}{2} a \text{Var}(Y) \right)$, is equivalent to maximize the expected value of $Y(p, q)$ and to minimize the variance of (29), that is the advantage provided by a price-quantity hedging portfolio.

In equation (33) it is presented the optimal hedging function constrained to the mean-variance utility function. The arithmetic procedure to find this expression is clearly developed.

$$x^*(p) = \frac{1}{a} \left(1 - \frac{g(p)/f_p(p)}{E^Q[g(p)/f_p(p)]} \right) - E[y(p, q) | p] + E^Q[E[y(p, q) | p]] \frac{g(p)/f_p(p)}{E^Q[g(p)/f_p(p)]} \quad (34)$$

where $f_p(p)$ is the marginal density function of p under the probability measure P .

From the perspective of a clearing house or a market maker, who is willing to design the most adequate hedging instruments for all the participants in the market, the goodness of this model, is that equation (34) can be used to calculate the optimal payoff function for each retailer, which will determine the optimal hedging instruments needed by each retailer. Once this task is undertaken, and seeking to find the optimal hedging instruments for all of them jointly interacting in the market, here it is proposed to estimate a weighted average market payoff function $\bar{x}(p)$ as presented in equation (35), which will represent the joint needs of all the agents and could be used to determine general hedging instruments - suitable for all-, by no favoring big or small agents and giving to each of them the same hedging opportunities.

$$\bar{x}(p) = \sum_{i=1}^N w_i x_i^*(p) \quad (35)$$

Where,

$$w_i = \frac{\int_0^S x_i^*(p) dp}{\sum_{i=1}^N \int_0^S x_i^*(p) dp} \quad (36)$$

The variable S corresponds to a price-cap value defined under the market maker or clearing house criteria. Within the Colombian framework, this variable could be interpreted as the scarcity price associated to the firm energy market described above, since hedging above this price already exists given the call options related to that market.

After calculating $\bar{x}(p)$, the replicating methodology suggested is used to find the right number of bonds, forward contracts, put, and call options needed to best describe the behavior of $\bar{x}(p)$.

Some of these financial instruments are currently available in the Colombian market, except the financial options. The simplest of them, bonds, can be found available in the stock market; forward contracts needed to replicate the function $x^*(p)$, could be either the current bilateral contracts (not suggested), the forward contracts that are planned to be included in MOR proposal, or even better, future contracts which are quite possibly to be launched the next year by a central chamber of counter-party risk (CRCC) to be established

soon in Colombia. Since there are no financial options to replicate the optimal hedging function on the current electricity market.

Now, for the empirical analysis and the estimation procedure we use data from the Colombian electricity markets daily market representative rate value (in Colombian Pesos) the period from January 1, 1995, to December 2 2013 with 6853 observations.

The fig 2 time series of the resulting price for the above Colombian electricity daily price.

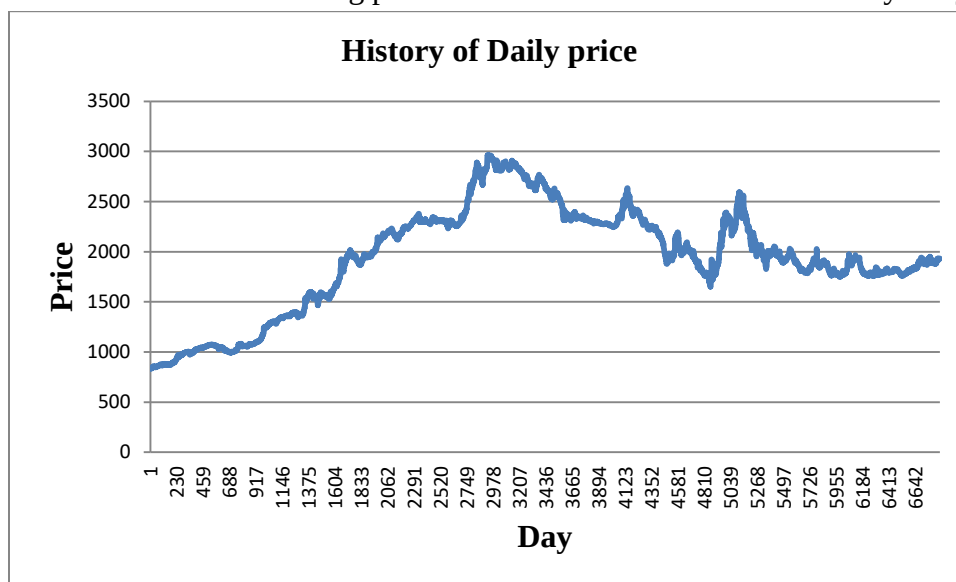


Fig 2: History of Daily price

The fig 3 gives the QQ plot for electricity daily price.

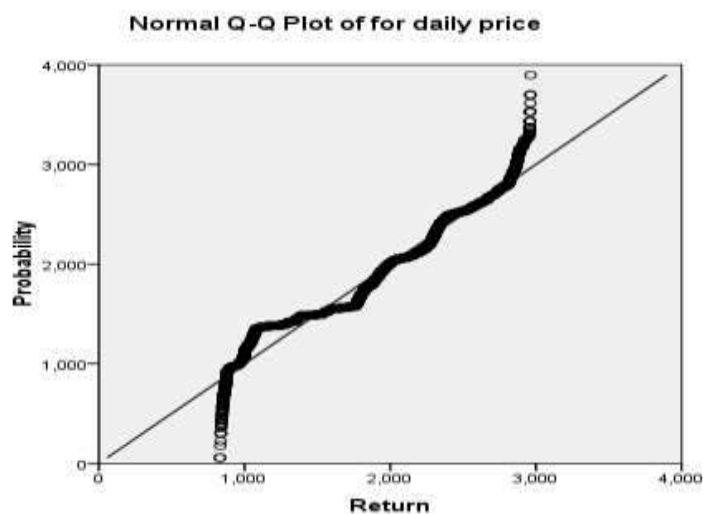


Fig 3: Normal QQ plot.

5. Conclusion

From the above discussion, in this paper we attempted to introduce an algorithm for pricing derivatives to intuition from Colombian electricity market. Initially we started our approach through to simple stochastic models for electricity pricing. And we derived analytical formulas for prices of electricity derivatives with different derivatives tools. 3) Then we extended short of the model for price risk in the electricity spot market. Finally, we constructed the model estimation under the physical measures for Colombian electricity market. And this paper end with conclusion.

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