Journal of Business Strategies, Vol.13, No.2, 2019, pp 31–48 *DOI:10.29270/JBS.13.2(19).03*

DETERMINANTS OF ELECTRICITY PRICES IN KARACHI: VAR ESTIMATION APPROACH

Madiha Saleem, and Nawaz Ahmad

ABSTRACT

New era presents the war for resources, and the balance of global interest has shifted from just land to energy. Countries are striving hard to become efficient in not only consumption but also the production of energy which is the new unit of power. Therefore, global focus is now moving towards the determination of factors that may aid the inefficient production of energy, mainly electricity rather than blind pursuit of energy sources. The visibility of this efficiency is the price at which electricity is available to consumers. Western counties like USA and Germany have performed various research studies to establish a list of factors, both economic and social, that influence overall electricity prices. Their approaches have primarily been empirical and point out towards the interest of even superpowers towards this topic. Pakistan being a developing country needs efficiency in the production of consumables to develop swiftly. The country has resources but lacks the technology to produce electricity efficiently. The largest city Karachi is overpopulated, and the demand for energy is ever rising, so are the shortages. This study employs Vector Auto-Regression (VAR) to study historical electricity prices in Karachi about electricity consumption, Gross Domestic Product and Oil Price. Results indicate that electricity prices are influenced directly by their first lagged values and negatively by GDP.

Keywords: *Electricity Prices, Electricity Consumption, VAR*

JEL Classification: *C32, Q41, Q43,*

INTRODUCTION

Karachi is the largest city of Pakistan. With the reach to warm waters and broad access to the Arabian Sea, there are numerous possibilities to trade from this important coast which is located in the emerging Asian

region. For the prosperity and definite progress, electricity is a significant utility which should be utilized efficiently for the economic growth of the country.

Without power today, there is no concept of progress since electricity is required by the majority of appliances and even locomotives now. Such dependence calls out for an extensive investigation on how the price patterns change so that the dependent industries and households may estimate and forecast possible scenarios and plan accordingly.

Prices of electricity can differ broadly from region to region and country to country or by some other boundaries named cities, provinces and states within a single country. The prices of electricity are factors dependent like the cost of power generation, transmission, distribution infrastructure, taxes, subsidies from the Government, and patterns of local weather. Many other features, such as multi-tiered industry regulation, that differentiate electricity from other commodities.

Currently, electricity has been treated as other supplies, although it has some particular features. Electricity is non-storable utility, and its demand needs to be fulfilled instantaneously. As a prediction, Demand has been found a significant variable of interest, as a change in centralized structure has been led from the liberalization of the power market. The estimation of electricity price, for both producer and consumer, has been observed as an unavoidable task (Martos, Rodriguez & Sanchez, 2011).

Energy is an expensive production input and has implications for the environment adversely. If the economy of a country has shown some growth or structure of the economy has been changing, which results in increased consumption of energy day by day. However, every society has a desire to keep that increase at its minimum level. Whereas, If consumption of energy increases without structural change or growth of the economy. It is a clear indication of the inefficiency of a country which shows that country is utilizing more energy for the same rate of production (He, Wang &Guang, 2020)

Scope of the study

The research is being performed for electricity price fluctuations and factors affecting electricity prices in Karachi. Therefore, the geographical scope of this research is limited to Karachi only.

Objective of the study

To study the impact of GDP, Heating Oil Price, and Electricity Consumption on Electricity Prices in Karachi

Research gap

The span of research (period) presents a limited trend which has a margin for more extension. Furthermore, only the factors affecting the prices of electricity in Karachi have been considered for this research. Data availability limited the scope of study too.

Statement of the problem

In the situation where gas prices and electricity consumption of Karachi are volatile, their effects on prices of electricity, i.e. the unit price of KE is required to be established which have yet not been identified by research for future reference or explanation of past price trends.

Research questions

1. Do the factors like Heating oil price, GDP and gross electricity consumption value affect electricity prices in Karachi?

2. What is the direction of the effect of identified significant explanatory variables on the dependent variable?

Hypotheses

H_1:There is no impact of GDP on electricity prices in Karachi.
H_2:There is no impact of Heating Oil price on electricity prices in Karachi.
H_3:There is no impact of Gross electricity consumption on electricity prices in Karachi.
H_4:There is no impact on the lag of Electricity Prices on Electricity Prices in Karachi.

LITERATURE REVIEW

Electricity has some salient characteristics such as spot volatility which in terms of financial assets become higher in magnitude as compare to other commodities (Karakatsani& Bunn, 2004). In the electricity market, the average daily electricity price demonstrates the electricity price to be supplied during the next full day and indicated as the main reference price. This study has been conducted for the daily average price in the Nord Pool market. It has been elucidated that disaggregated hourly prices have useful analytical and predictive insights for the average daily price (Raviv, Bouwman & Dijk, 2015). Until initial 90s electricity prices have been secured or fixed by

regulators mainly depending on generation cost, transmission cost and distribution cost, which leads a little uncertainly in electricity prices. However, competition has been introduced in generation and supply activities in the last two decades. The reform has been evolved in consequence of the interaction between supply and demand (generators and supplier to consumers) and commonly known as pool (Escribano, Pena &Villaplana, 2011).

Research in the UK has been performed using multivariate OLS regression to find out the relative consumption drivers effect for heating on gas. The marginal contributions of each factor to the consumption of energy have been discussed in the study by using standardized coefficients. The findings indicate that prevailing practice policy emphases mainly on dwelling characteristics(Fuerst, Kavarnou, Singh & Adan, 2019).

Silva and Cerqueira (2017) have explored the impact of different economic variables on prices of household electricity by using econometric panel data techniques. They have presented their research scope on the electricity industry value chain via the market opening of the generation segment. As after the first set of European directives, generation segment was expected to be the most progressive segment. Consumer electricity prices are expected to be affected by generation segments as wholesale market transfer electricity to retails. The results of the study have indicated that increased trends of market liberalization in few scenarios come with a decrease in concentration and new actors of the market. Also desired decrease in household electrical prices are the outcomes of increased trends of market liberalization. Whereas, no adverse impact on the household paid prices have been evident in the result of regulated prices. Aqeeq, Hyder, Shehzad and Tahir (2018) have presented a research study, and for five years respectively, results show economic competitiveness of electricity PV, with an IRR and payback averaging approximately 28%.

A study was performed recently in 2019 for the prediction of the price of electricity based on forecasted aggregate purchase and sales curve. The researcher had to model the purchase and sales curve hourly bases, to identify the intersection of the forecasted curves to get the forecasted equilibrium market volume and price. Functional data analysis methods have done it, namely, parametric (FAR) and nonparametric (NPFAR) functional autoregressive models and results have been compared to benchmarks (Shah &Lisi, 2019).

Carmona and Coulon (2013) have discussed structural models in their extensive research work. The structural models which have been parented meet the criteria by directly incorporating capacity, demand and prices of fuel and also the mathematical benefits conventionally associated with reduced-form approaches have not been compromised. However, they did recommend thinking beyond the price services evident historically. Kabak and Tasdemir (2020) have studied recently that the price of electricity has a dynamic structure, and many factors affect that structure directly or indirectly. Market transactions have now being carried out on forecasting based contracts. Usually, the transactions are based on the day-ahead market (DAM) and one day before balancing the power market, also an intra-day market half hour before, mid and long term for market derivatives. Researchers have purposed a short-term price forecasting model by examining historical data which have affected the price most appropriately that have been correlated by using artificial neural network method.

Jamil and Ahmad (2010) have performed in-depth research using the four main categories (residential, commercial, agricultural and manufacturing) and taken data for aggregate series from 1960 to 2008 time period. They carried out the inter-relationship in a multivariate co-integrated system between consumption of electricity, price of electricity and economic growth. Also, the existence of a long-run equilibrium relationship has been found between three variables via co-integration. However, short term deviation may exhibit for electricity consumption and output but eventually turn to long-run equilibrium.

The internal enterprise factors such as labour and remuneration costs have a direct effect on the real costs of the electricity distribution enterprise, which has been established by the estimated cost function. During market deregulation and price liberalization of electricity, the real cost of purchasing did not significantly reduce for distribution enterprise. There are possible sources of market power for electricity producers, wholesalers and the electricity distribution enterprise (Papler&Bojnec, 2016).

Lucia and Schwartz (2002)have observed the behaviour of electricity prices and the importance of regular patterns and implications for the secondary pricing purpose. This study has been conducted for Europe and analyzed the Nordic Power Exchange's spot, its futures, and the forward prices of electricity. Furthermore, the researchers concluded that systematic seasonal patterns importantly explain futures or forward curve

shapes during the whole year. The seasonal patterns of the futures and forward curve can be adequately carried out by a simple sinusoidal function, which is directly implied spot prices seasonal behaviour.

Wang, Zhang and Zhang (2012) have researched in China on reforms of tiered electricity price. They had identified the determinants of the willingness of TEP among Chinese civilians and they moreover had tried to find out the tolerable range of premium for chines people. They had taken an ordinary regression model for their analysis, and the main purpose is to identify factors of TEP acceptance to the general public. Results indicated that TEP had been opposed strongly by the middle-class group. Whereas, highlighted TEP implications are public environmental awareness, including economic factors. Although studies had not found cost as a statistically significant determinant, in urban cities of China, tolerable TEP premium rate had identified below 0.05 RMB/kW h in their piece of research.

A study has been conducted to provide a real-time relationship between total peak demand and spot market prices and its quantification. A researcher has found a low value for the real-time price elasticity. This may justify in a way that not all users or consumers observe the spot market price. For the generalizability to all users, limited scope for government intervention in supply security issues would be implied in that case (Lijesen, 2007).

Another study was performed in Europe in 2008, with particular attention to the European energy exchanges paper has been offered the most salient statistical features of electricity prices. A researcher has used sum-OU model, i.e., a model representing the price as a sum of L´evy-driven Ornstein Uhlenbeck (OU) processes, and showed a relatively new method for filtering out the different OU components. Also, the researcher has developed a statistical procedure for estimating the sum-OU model from data(Brandis& Tankov, 2008).

Hirth(2018) has studied two countries Germany and Sweden and found both countries differ significantly as fuel and CO_2 prices identified as a significant price driver in Germany whereas in Sweden, electricity demand was found as an essential driver. This difference is elucidated and justified by the single leading factor, i.e., expansion of renewable energy. The study has been performed in Australia during 2010, which suggests factor models-DSFM for the hourly electricity prices behaviour with the use of dynamic semiparametric. Researchers have been concluded that the three-

factor model has explained variation in hourly electricity prices with high proportion. They have also focused on the characteristics of the market, particularly concerning the factors of hourly electricity prices and its dynamic behaviour with time (Hardle&Truck, 2010).

Kirschen, Strbac, Cumperayot, and Mendes (2000) have discussed in their study about the elasticity demand of electricity and how it could be taken into account for the price setting in the competitive centralized market. Also, the concept of cross elasticity has been taken for checking consumer react to the volatility of electricity prices. Karakatsani and Bunn (2008) have investigated and discussed in detail about the two model characteristics to check the influence on day-ahead price forecasting. The two characteristics include fundamental of markets that affect the formation of price and specification of time-varying effects. Wolde-Rafael (2006) has been established a relationship between electricity consumption and economic growth with a time series data for 17 African countries.

It has been derived from the electricity market, which shows that electricity per hour prices significantly depend on electricity demand. Moreover, demand shows hourly, daily and seasonal fluctuations which are directly or indirectly influenced by gross domestic product (GDP) and economic activity of the country (Gareta, Romeo & Gil, 2005).

In Germany, Schwarz and Lang (2006) have tried in detail to compute the significance of fundamental variables for increasing trend of fluctuating electricity prices in the wholesale market. Factors include rising fuel cost, CO_2 emission factor fuel, CO_2allowance price, hot start-up and abrasion costs. It has been observed that electricity prices data in time series shows non-stationarity form, in the long term]behaviour, sometimes one or more periodic components exhibits a dependence on calendar effects. This behaviour of data allows us to account for both long term and periodic components in electricity prices modelling (Lisi& Nan, 2014). Public discontent or dissatisfaction caused in a result of increasing utility prices which has been getting intensified day by day. Although regulators are enforced from external pressures to alter practices and behaviours, thus, researchers have presumed regulators more than the mediators between producers and punchers (Primeaux, Jr.& Mann, 1986).

In California, Joskow and Kahn (2002) have studied that increase in demand, increased gas prices and reduction in the availability of power

imports with high emission permits prices significantly affects the higher wholesale market price. It has been observed that during summer, high wholesale electricity prices have been observed as a natural seasonal outcome considering the competitive nature of the market. Whereas, a significant gap has been found between market price and its benchmark price.

Another research has been done in Spain. The researcher has purposed and analyzed the Hidden Markov Model (IOHMM) for spot electricity prices forecasting. The predictions about the accuracy and information dynamics about the market have been proved good in model testing which in turn helped in identification and characterization of more relevant explanatory variables (González, Roque & González, 2005). In 2005, researchers conducted in-depth research to identified price differences caused by different variables such as climate change, mix fuel, cost of fuel and effects of ISO. They have used four classes for grouping of customers. They have included both nominal and real prices and three regulatory status definitions. Also, the study has not found empirical support in generalizability as customers of deregulated states have lower rates than customers of regulated states (Taber, Chapman &Mount, 2005).

Conceptual model

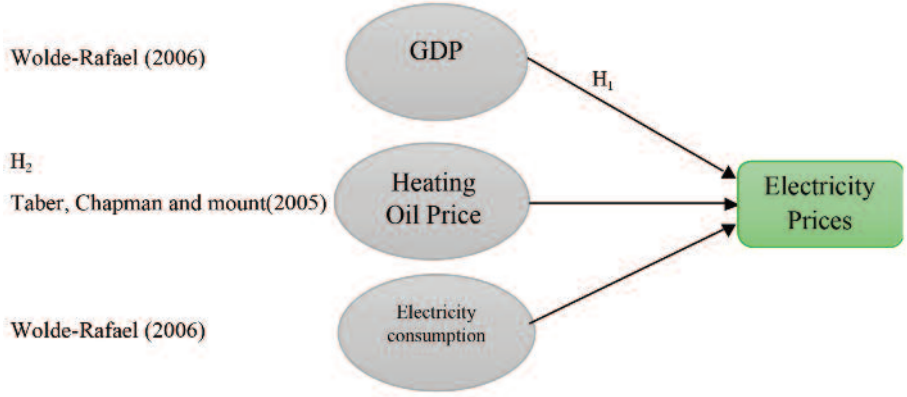

Figure 1: Conceptual Model

METHODOLOGY

Data

This research is based on secondary data collected from credible sources such as the State Bank of Pakistan's and KE official website. Nature of data is time series as yearly data has been taken from 1981 to 2020 (40 years).

Independent Variable

Real gross domestic product (GDP) is a measure of economic output adjusted for price changes such as inflation or deflation. Data has been taken in Billion-USD for GDP.

Heating Oil price (OP)is a price of fuel oil, used in industrial heating equipment for burning. International heating oil price is measured in per Ton USD.

Gross electricity consumption (EC) is a total unit of electricity consumed per year by Karachi City. Consumption of electricity is measured in kilowatt-hours.

Lag values of Electricity Prices (EP) are the unit price of electricity charged by Karachi Electric (KE). Electricity price is measured in Rs/Kw.

Dependent Variable

Electricity Price (EP) is the unit price of electricity charged by Karachi Electric (KE). Electricity price is measured in Rs/Kw.

Sample size

Since secondary data will be used in this research, the GDP, heating oil prices and electricity have been adopted. Aim of this study is to determine the effects of electricity prices on Karachi. Therefore,40years' data has been taken only for Karachi from KE and State Bank of Pakistan.

Statistical model

Data is time-series in nature, and when each series was tested, it was found to be stationary at first difference. Hence all the series are of the same order of integration, and Vector Auto Regression (VAR) is the suggested test for this case.

RESULTS AND DISCUSSION

Graphical analysis

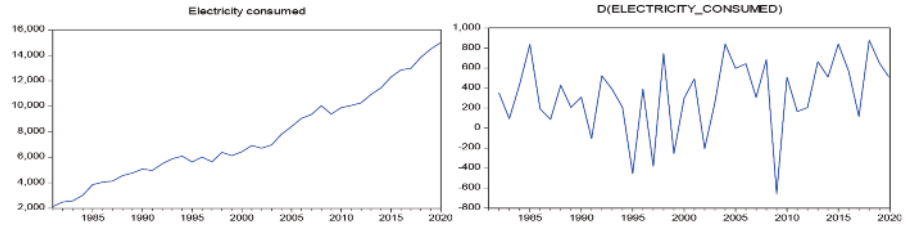

Figure 2: Trending and De-trending of Electricity Consumed

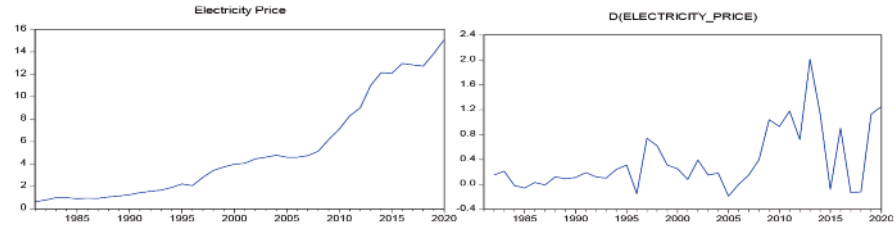

Figure 3: Trending and De-trending of Electricity Price

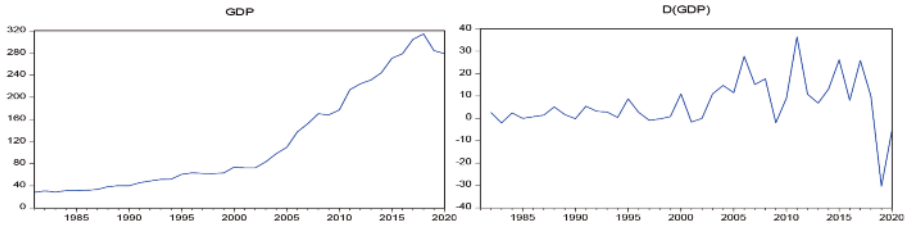

Figure 4: Trending and De-trending of GDP

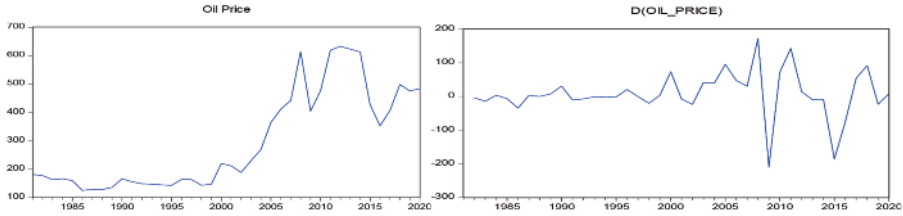

Figure 5: Trending and De-trending of Oil Price

From Figure 2 to Figure 5, trending and de-trending of variables have been presented. De-trending of data is the graphical presentation of first difference for EP, EC, OP and GDP whereas, trending of data is the graphical presentation of raw data for EP, EC, OP and GDP.

Unit Root test

The unit root test results indicate that all the variables have unit roots at the level. Therefore, the first difference was evaluated, and it was found that they are all stationary at first difference.

Table 1: Unit root test results

Variable	T-statistic	p-value	Stationary at
Electricity Consumed	-6.932943	0.0000	*I*(1)
Electricity Price	-3.424083	0.0162	*I*(1)
GDP	-4.269522	0.0017	*I*(1)
Oil Price	-6.417864	0.0000	*I*(1)

Table 1 shows the unit root test results summary for all the variables. Electricity

consumed, GDP, and Oil Prices have p-values less than 0.01 whereas Electricity Price has p-value less than 0.05 which suggest that the variables are integrated of order one, i.e. *I*(1), so the first difference will be used in further analysis.

Descriptive statistics

Table 2: Descriptive Analysis

	D(ELECTRICITY_ CONSUMED)	D(ELECTRICITY_ PRICE)	D(GDP)	D(OIL _PRICE)
Mean	330.1026	0.371026	6.430754	7.766154
Median	388.0000	0.180000	3.183216	-0.260000
Maximum	879.0000	2.010000	36.42178	172.2200
Minimum	-656.0000	-0.190000	-30.37821	-209.9000
Std. Dev.	369.1475	0.496253	11.11713	67.78128
Skewness	-0.764927	1.331969	-0.010515	-0.804281
Kurtosis	3.217082	4.367381	5.707701	6.303820
Jarque-Bera	3.879809	14.57023	11.91464	21.94188
Probability	0.143718	0.000686	0.002587	0.000017
Sum	12874.00	14.47000	250.7994	302.8800
Sum Sq. Dev.	5178256.	9.358159	4696.445	174583.5
Observations	39	39	39	39

Jarque-Bera probability value for EC is 0.143718 which is greater than 0.05 which indicates that data set is standard whereas, Jarque-Bera p-value for EP, OP and GDP is less than 0.05 which depicts that data set is not typical. EC, GDP and OP data is negatively skewed, indicating that it has a tail to the left side but tilt to the right. Although EP data is positively skewed, all four datasets are Lepto-kurtic since the Kurtosis values are greater than 3.

Econometrical Analysis

Table 3: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
GDP does not Granger Cause OP	37	0.81858	0.4938
OP does not Granger Cause GDP		9.05149	0.0002
EP does not Granger Cause OP	37	0.53012	0.6651
OP does not Granger Cause EP		3.67878	0.0228
EC does not Granger Cause OP	37	1.44785	0.2485
OP does not Granger Cause EC		0.17886	0.9099
EP does not Granger Cause GDP	37	2.87634	0.0525
GDP does not Granger Cause EP		7.15662	0.0009
EC does not Granger Cause GDP	37	0.96422	0.4224
GDP does not Granger Cause EC		1.67849	0.1926
EC does not Granger Cause EP	37	3.45367	0.0287
EP does not Granger Cause EC		3.28579	0.0342

Table 3 shows the results of the Granger causality test, which indicates

that Oil Price, GDP, and Electricity Consumption, which are taken into consideration as determinants of Electricity Price, all Granger cause Electricity Price at 5%, 1%, and 5% respectively. Electricity Price has two-way causation with Electricity Consumption only. Other variables like Oil Price Granger cause GDP at 1%. There is no other causality between any set of variables.

To get more insights for the study variable, i.e. Electricity Price, VactorAutoregression (VAR) model is applied to consider the lag impact as well. To decide the number of lags for the model, VAR lag selection criteria are tested first to determine the number of lags for the VAR model.

Table 4: VAR Lag Order Selection Criteria

VAR Lag Order Selection Criteria
Endogenous variables: D(EP)
Exogenous variables: D(EC) D(GDP) D(OP)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-31.80781	NA	0.405059	1.933767	2.065727	1.979825
1	-23.77336	14.28347*	0.274174	1.542964	1.718911	1.604374
2	-21.88401	3.253878	0.261188	1.493556	1.713489*	1.570319
3	-20.13512	2.914817	0.250878*	1.451951*	1.715871	1.544066*

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4 shows the VAR Lag selection criteria in which three lag have been selected based on the Akaike Information Criterion (AIC).

Table 5:Vector Auto-Regression Estimates

	D(EP)
D(EP(-1))	0.558727
	(0.17374)
	[3.21582]
D(EP(-2))	0.285021
	(0.22915)
	[1.24382]
D(EP(-3))	0.333777
	(0.19077)
	[1.74961]
D(EC)	-2.66E-05
	(0.00020)
	[-0.13115]

D(GDP)	-0.018417 (0.00868) [-2.12239]
D(OP)	0.001488 (0.00138) [1.07567]
R-squared	0.292161
Adj. R-squared	0.174188
Sum sq. resids	6.451158
S.E. equation	0.463723
F-statistic	2.476501
Log-likelihood	-20.13512
Akaike AIC	1.451951
Schwarz SC	1.715871
Mean dependent	0.392500
S.D. dependent	0.510291

D(EP) = 0.558727 D(EP(-1)) - 0.018417 D(GDP)

Table 5 shows the Vector Auto-regression Estimates.Coefficient of D(EP(-1)) and D(GDP) have been taken into account as they are significant (based on their t-statistics) to formulate the equation for D(EP). R-squared is 29.2%, whereas Adjusted R-squared is 17.4%. As both values are not close, it indicates that we have used a smaller number of observations and by increasing the observations, the Adjusted R-squared will be improved.

Hypotheses assessment summary

Table 6: Hypotheses Assessment Summary

No.	Hypotheses statement	Remarks
H_1	There is no impact of GDP on Electricity Prices in Karachi	Rejected
H_2	There is no impact of Heating Oil Price on Electricity Prices in Karachi	Retained
H_3	There is no impact of Gross Electricity Consumption on Electricity Prices in Karachi	Retained
H_4	There is no impact of the lag value of Electricity Prices on Electricity Prices	Rejected

Table 6 shows an overall summary of the hypotheses on the bases of its rejection and retention. GDP and the first lag of Electricity Prices are significant estimators of Electricity Prices whereas Oil Prices and Electricity Consumption are not found to be significant estimators of Electricity Prices.

Discussion

The results vary and yet at the same time present some agreement with

the evidence found in theory. In African countries, fuel prices were found to influence electricity prices via literature Wolde-Rafael (2006). However, empirically it was found that fuel prices were insignificant to impact electricity prices in Karachi. Also, Hirth (2018) has found that Germany and Sweden differ significantly as fuel prices recognized as a significant price driver in Germany as in Sweden. Also, electricity consumption (taken as a proxy for demand), does not impact electricity prices in Karachi whereas

However, the discussion about reforms and economic variables have found to be useful in this case as GDP has turned out to be a significant variable in impacting the electricity prices same was studied for 17 countries of Africa (Wolde-Rafael, 2006). The relationship is inversely showing that as the GDP decreases, electricity prices increase. However, there is a new finding that was not found in the studied literature. Electricity prices depend directly on their lagged value. Meaning that increased values tend to cause further enhancement in electricity prices in Karachi.

CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

Conclusion

In partial agreement with the literature, it was found that the Electricity Prices in Karachi are directly proportional to their first lagged value and inversely proportional to the GDP. None of the other variables, including Oil Prices and Electricity Consumption, were found to predict the Electricity Prices. These results were found via Vector Auto-Regression method while Granger causality indicated Oil Prices and Electricity Consumption also to affect Electricity Prices.

Limitations

Observations were limited, higher no. of observation may generate better results. Difference between R-squared and Adjusted R-squared was, therefore, also high. Data only on Karachi city cannot let this research to be generalized for the whole country. Also, data from other major cities like Lahore, Islamabad, Peshawar and Quetta may present a better picture if included in the empirical study as panel data.

Recommendations

From the evidence presented in this research, the Government should place reforms according to which consumers may not face enormous

electricity price hikes based on fuel price and electricity consumption changes. Instead, the electricity price forecast should be related to economic factors like GDP and measures for its stabilization should be taken. In that way, electricity prices may be controlled realistically.

REFERENCES

Alonso, A. M., García-Martos, C., Rodríguez, J., &Jesús Sánchez, M. (2011). Seasonal dynamic factor analysis and bootstrap inference: application to electricity market forecasting. *Technometrics*, *53*(2), 137-151.

Aqeeq, M. A., Hyder, S. I., Shehzad, F., & Tahir, M. A. (2018). On the competitiveness of grid-tied residential photovoltaic generation systems in Pakistan: Panacea or paradox? *Energy Policy*, *119*, 704-722.

Bojnec, Š.,&Papler, D. (2016). Deregulation of electricity market and drivers of demand for electrical energy in industry. *Management and Production Engineering Review*, *7*(3), 4-10.

Carmona, R., & Coulon, M. (2013). A Survey of Commodity Markets and Structural Models for Electricity Prices. *Quantitative Energy Finance*, 41–83. doi: 10.1007/978-1-4614-7248-3_2

Da Silva, P. P., & Cerqueira, P. A. (2017). Assessing the determinants of household electricity prices in the EU: a system-GMM panel data approach. *Renewable and Sustainable Energy Reviews*, *73*, 1131-1137.

Escribano, A., Ignacio Peña, J., &Villaplana, P. (2011). Modelling electricity prices: International Evidence. *Oxford bulletin of economics and statistics*, *73*(5), 622-650.

Fuerst, F., Kavarnou, D., Singh, R., & Adan, H. (2019). Determinants of energy consumption and exposure to energy price risk: a UK study. *ZeitschriftfürImmobilienökonomie*, 1-16.

Gareta, R., Romeo, L. M., & Gil, A. (2006). Forecasting of electricity prices with neural networks. *Energy conversion and management*, *47*(13-14), 1770-1778.

González, A. M., Roque, A. S., &García-González, J. (2005). Modeling and forecasting electricity prices with input/output hidden Markov models. *IEEE Transactions on power systems*, *20*(1), 13-24.

Härdle, W. K., &Trück, S. (2010). The Dynamics of Hourly Electricity Prices. *SSRN Electronic Journal*, 1-23. doi: 10.2139/ssrn.2894267.

Hirth, L. (2018). What caused the drop in European electricity prices? A

factor decomposition analysis. *The Energy Journal*, *39*(1), 143-157.

Jamil, F., & Ahmad, E. (2010). The relationship between electricity consumption, electricity prices and GDP in Pakistan. *Energy Policy*, *38*(10), 6016-6025.

Joskow, P. L., & Kahn, E. (2002). A quantitative analysis of pricing behavior in California's wholesale electricity market during summer 2000. *The Energy Journal*, *23*(4), 1-37.

Kabak, M., & Tasdemir, T. (2020). Electricity Day-Ahead Market Price Forecasting by Using Artificial Neural Networks: An Application for Turkey. *Arabian Journal for Science and Engineering*, *45*(3), 2317-2326.

Karakatsani, N. V., & Bunn, D. W. (2004, March). Modelling the volatility of spot electricity prices. In *2nd Energy Risk Management Seminar*.

Karakatsani, N. V., & Bunn, D. W. (2008). Forecasting electricity prices: The impact of fundamentals and time-varying coefficients. *International Journal of Forecasting*, *24*(4), 764-785.

Kirschen, D. S., Strbac, G., Cumperayot, P., & de Paiva Mendes, D. (2000). Factoring the elasticity of demand in electricity prices. *IEEE Transactions on Power Systems*, *15*(2), 612-617.

Lijesen, M. G. (2007). The real-time price elasticity of electricity. *Energy Economics*, *29*(2), 249-258.

Lisi, F., & Nan, F. (2014). Component estimation for electricity prices: Procedures and comparisons. *Energy Economics*, *44*, 143-159.

Lisi, F., & Shah, I. (2019). Forecasting next-day electricity demand and prices based on functional models. *Energy Systems*. doi: 10.1007/s12667-019-00356-w

Lucia, J. J., & Schwartz, E. S. (2002). Electricity prices and power derivatives: Evidence from the Nordic power exchange. *Review of derivatives research*, *5*(1), 5-50.

Meyer-Brandis, T., &Tankov, P. (2008). Multi-factor jump-diffusion models of electricity prices. *International Journal of Theoretical and Applied Finance*, *11*(05), 503-528.

Primeaux, W. J., & Mann, P. C. (1986). Regulator selection methods and electricity prices. *Land Economics*, *62*(1), 1-13.

Raviv, E., Bouwman, K. E., & Van Dijk, D. (2015). Forecasting day-ahead electricity prices: Utilizing hourly prices. *Energy Economics*, *50*, 227-239.

Schwarz, H. G., Lang, C., & Meier, S. (2007). Market Power in the German Wholesale Electricity Market: What are the Political Options? *SSRN 1028201*.

Taber, J. T., Chapman, D., & Mount, T. D. (2005). Examining the effects of Deregulation on retail electricity prices.

Wang, Z., Zhang, B., & Zhang, Y. (2012). Determinants of public acceptance of tiered electricity price reform in China: Evidence from four urban cities. *Applied Energy*, *91*(1), 235-244.

Wolde-Rafael, Y., 2006. Electricity consumption and economic growth: a time series experience for 17 African countries. *Energy Policy, 34*(10), 1106–1114

Ye, L. (2003). Study on sustainable development strategy of electric power in China in 2020. *Electric Power*, *36*(10), 1-7.