An Analysis of Competition in Short Term Power Market in India

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ABSTRACT

The Indian Electricity Sector has been undergoing a breakthrough reforms process to increase the competitiveness of the sector. Competition is not usually preferred by the suppliers because less competition provides sellers a greater pie in the profit share of the market. Increase in the competition implies less entry exit barriers, large number of suppliers and buyers, reduction in the transaction cost, freedom to set prices, decrease in the market power of firms. The present study tries to introspect the level of competition in the short term power market in India since the inception of the power exchanges in the year 2008 by using the Hirschman Hirfindahl Index (HHI) which takes the volume of electricity transacted by the traders in the market. It also uses the VAR model to check the causality of the price of electricity with the HHI and number of traders in the short term power market.

Keywords: short term power market, power exchanges, competition, Hirschman Hirfindahl Index.

1. INTRODUCTION

The reforms in the power sector of India were initiated with the objective of promoting competition in different segments of the electricity sector in India. In 2003, the Electricity Act was enacted with the various other policy initiatives to promote competition and transform the power sector of the country. The Central Electricity Regulatory Commission (CERC) which was formed in 1998, has also facilitated competition by creating the regulatory framework of Indian Electricity Grid Code, Availability Based Tariff, inter-state trading, power exchanges and open access in inter-state transmission.

These initiatives have decreased the electricity prices in the short term power market many folds. The average price of electricity transacted through traders decreased from 7.29 (rupee/kWh) in 2008/09 to 4.11 (rupee/kWh) in 2015/16. The weighted average of electricity tariffs transacted through the power exchanges decreased from 7.49 (rupee/kWh) to 2.72 (rupee/kWh). Despite the fall in the prices, there is a wide difference between the prices of the different regions in the country which is due to inadequate transmission facilities. Even the volume of electricity actually traded at power exchanges is less than the scheduled volume to be traded at power exchanges which is chiefly caused due to the unavailability of transmission lines. The problem of inadequate transmission

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lines has given undue advantage to the firms in the form of higher prices which has increased the market power of the firms in a region.

Robinson and Baniak (2002) have shown in their study of English and Welsh electricity pool that the generators with the market power have an incentive to create volatility in the spot market. Ahmad M. I. (2017) has determined the seasonal variation of the electricity consumption in Oman. In which the author found that the volatility in electricity demand due the seasonal variation has also led to the increase in the market power of firms during peak demand season. There can be many reasons for the difference in the prices of electricity in the different regions.

The present paper tries to investigate whether market power has been a reason for the increase in the price of a region creating a difference in the price with other regions. Using the data from the short term power market reports of the Central Electricity Regulatory Commission, this paper analyses the market structure and competition level in the short term electricity market in India. The period of the study is from 2008/09 to 2015/16; 2008 being the year of inception of the power exchanges and the initiation of a formal market platform for power trading in India.

2. THE SHORT TERM POWER MARKET IN INDIA

As per Central Electricity Regulatory Authority the "short-term transactions of electricity refers to contracts of less than one year period for electricity transacted under bilateral transactions through inter-state trading licensees (only inter-state part) and directly by the distribution licensees (also referred as Distribution Companies or DISCOMs), power exchanges (Indian Energy Exchange Ltd (IEX) and Power Exchange of India Ltd (PXIL), and Deviation Settlement Mechanism (DSM)". The short term transactions are done to meet the short run requirements of the electricity which is caused due to seasonal fluctuations in demand for electricity in India.

In 2015/16, the short term power market comprises 10 percent of the total electricity procured in India. The balance 90 percent is procured mainly by distribution companies through the long term contracts. The volume of short term power transactions increased from 65.90 billion units (BU) in 2009/10 to 115.23 billion units (BU) in 2015/16.

Table 1: Volume of short term transactions

Year	Volume of Short-term Transactions of Electricity (BU)	Total Electricity Generation (BU)	Volume of Short-term Transactions of Electricity as % of Total Electricity Generation
2009/10	65.90	768.43	9
2010/11	81.56	811.14	10
2011/12	94.51	876.89	11
2012/13	98.94	912.06	11
2013/14	104.64	967.15	11
2014/15	98.99	1048.67	9
2015/16	115.23	1107.82	10

Source: NLDC & CEA

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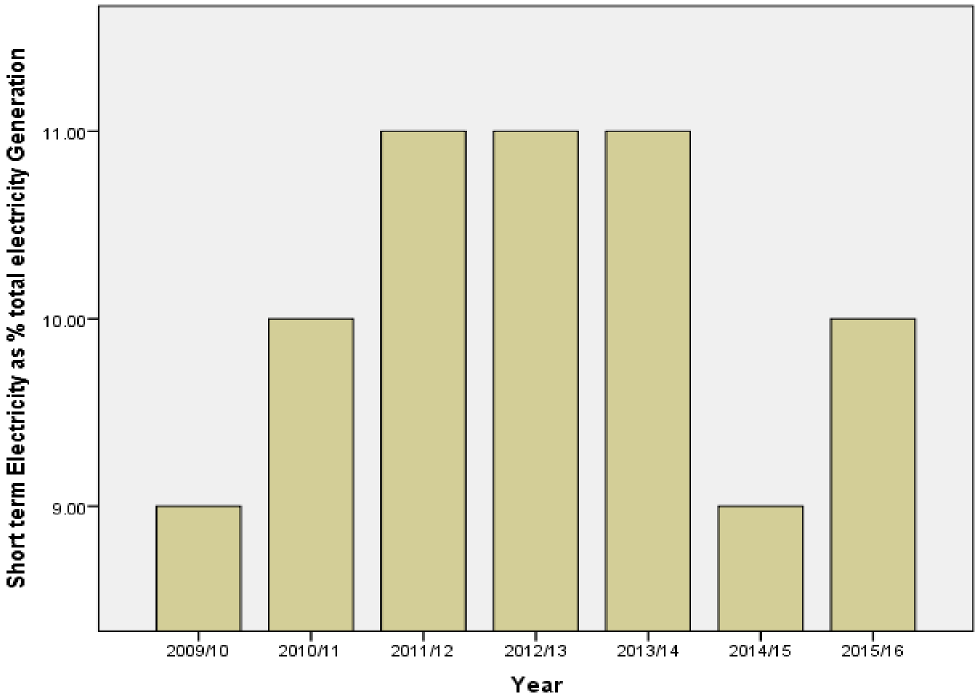
The data in table 1 show that the volume of short term transactions has increased from 2009/10 to 2015/16 with the increase in the total electricity generation. However, the share of short term transactions as a percentage of total electricity generated has remained around 10 percent. It is expected that the share of short term power market will change in the next ten years because a number of companies that have already entered into a long term contract in order to fulfil their electricity demand are expected to terminate these contracts in the near future due to falling prices of short term power, and thus there will be an increased volatility in the volume of electricity due to high demand consequent upon increasing population. The share of short term power market in developed countries ranges from 23 percent to 80 percent whereas in India the market is still at a nascent stage. Figure 1 reflects the growth of short term power market in India since 2009/10.

Figure 1: Growth of short term power market



Source: CERC 2015/16

3. TRADING MECHANISM IN SHORT TERM POWER MARKET

The electricity in the short term power market is transacted in following ways

- Short term bilateral contracts: The electricity transacted by these bilateral contracts are traded by only those companies who have interstate and interregional trading licenses, and it requires open access network through the central transmission utility. The purchase and sale of power take place mostly by the traders who have the license granted by the central electricity regulatory commission. The volume of the power traded by the short term bilateral contracts has grown from 26.72 BU in 2009/10 to 35.43 BU in 2015/16.

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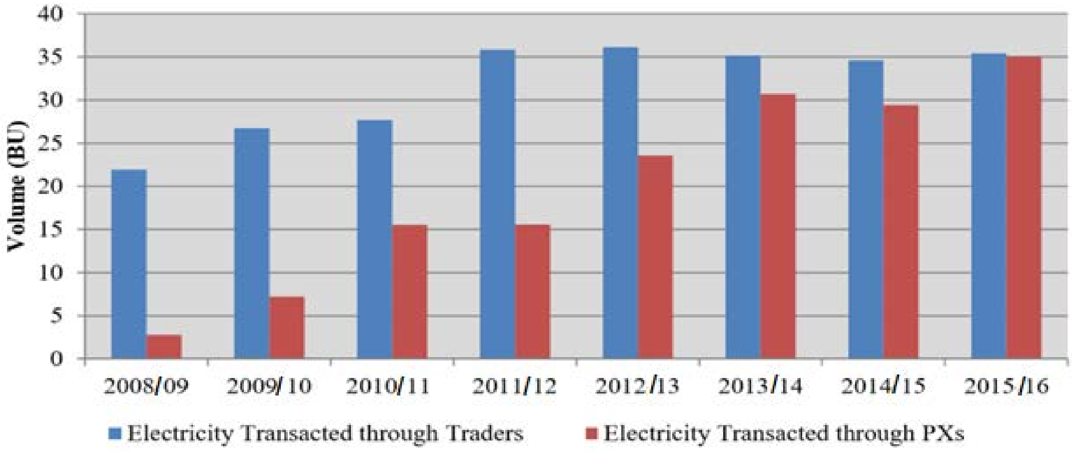
Figure 2: Electricity transacted through traders and power exchanges



Source: CERC 2015/16

- Power Exchanges: In 2007, the CERC issued guidelines for the setting and operation of the power exchanges in India which resulted in the opening up of India's first power exchange, India Energy Exchange limited (IEXL) in June 2008, which was followed by Power Exchange of India Limited (PXIL) in October 2008. These power exchanges offer a double-sided closed auction in which the demand and supply of the electricity decide the equilibrium price. The electricity traded on the power exchange is delivered on the following day which is also known as day ahead market. If there is any congestion in the transmission network, then the price will be discovered separately in a region. All the buyers and sellers of the congested region bear transmission charges and losses of their regional transmission network. They will also bear the transaction fee of the exchange and the operating costs of the system. Once the power is scheduled and if the actual drawl or generation deviates from the scheduled power then this difference is settled by the unscheduled interchange. The volume of short term transactions through power exchanges have grown from 7.19 BU in 2008/09 to 35.01 BU in 2015/16.

- Unscheduled Interchange/Deviation Settlement Mechanism: It is a mechanism through which surplus electricity in the system is traded. If the actual generation of a generating company deviates from the scheduled generation, then the company needs to pay the UI charges. Along the same lines for the buyer of the electricity, if the actual drawl deviates from the scheduled drawl, then he accounts for the UI charges. To calculate the unscheduled charges the scheduled energy is compared with the metered energy in each 15 minute time block and the deviation whether it is plus or minus becomes the UI. The UI rate is calculated by taking the average of the frequency for 15 minute time. All the payments of the UI are managed by Regional Load Despatch Centres (RLDCs) through a regional pool account.

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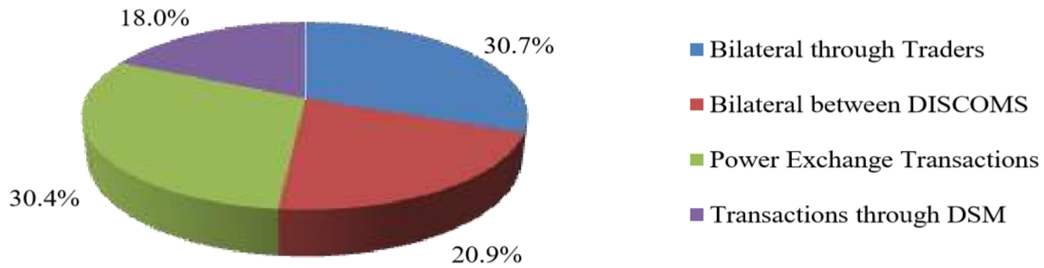
The volume of UI transactions fell from 25.81 BU in 2008/09 to 20.75 BU in 2015/16.

- Electricity traded by the distribution licensees: The distribution companies are also dependant on the short term power market to meet their seasonal fluctuations in demand. In this market, the discoms with the surplus power sells electricity to the discoms with deficit power. These distribution companies enter in the short term contract to transact electricity with each other. The volume of electricity traded by the distribution licensees increased from 6.19 BU in 2008/09 to 24.4 BU in 2015/16.

Figure 3: Share of different segments in Short term power market during 2015/16



Source: CERC 2015/16

Fig.3 highlights that during 2015/16, transactions through traders and power exchanges comprised of more than 60 percent of the total short term transactions.

4. COMPETITION IN THE SHORT TERM POWER MARKET

The competition in the short term power market has increased many folds. Since the inception of the power exchanges the number of buyers and sellers in the day ahead market and term ahead market increased many folds, and at the same time, the number of traders in the market have also increased. The level of competition can be investigated by a decrease in the price of electricity from the year 2008/09 to 2015/16.

The electricity transacted through traders contribute nearly 30 percent of the total short term market. To analyze the market power of the traders, we have used the Hirschman Hirfindahl Index (HHI). The Hirschman Hirfindahl Index is a standard measure which is used to measure the market power of the firms. It is calculated as the sum of squares of the market share of all the firms in the industry, and its value lies between 0 and 1. The maximum value of one shows that the firm is enjoying the monopoly in the market and as it approaches zero the competition increases in the market. Equation (1) reflects the formula of HHI.

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$$\text{HHI} = \sum_{i=1}^{n} S_i^2 \qquad \dots\dots (1)$$

where S_i is the firm i's market share, n is the number of firms

The HHI between 0.10 to 0.18 indicates moderate concentration and HHI above 0.18 indicates a high concentration in the electricity market.

Table 2 shows the share of electricity traded by major licensees during 2009/10 to 2015/16. The HHI for the top 5 traders in 2009/10 is 0.23 which indicates high concentration which means that the market power of affecting the price and output lies with only a few big firms. In 2015/16 the HHI for the top 5 traders is 0.1432 which indicate a decrease in the concentration of market power among the traders. The HHI of the major trading licensees like Power Trading Corporation (PTC) India, Tata Power went down to 0.086 and 0.016 respectively from high concentration during the period 2009/10 to 2015/16.

Table 2: Share of electricity traded by licensees and HHI

Name of the Trading licensee	Year			
	2009/10		2015/16	
	Share of electricity traded by licensees(in %)	HHI	Share of electricity traded by licensees(in %)	HHI
PTC India Ltd.	42.89	0.18	29.31	0.086
Tata Power Trading Company (P) Ltd.	9.83	0.01	12.74	0.016
Mittal Processors (P) Ltd.	0.4	0	12.07	0.015
JSW Power Trading Company Ltd	7.92	0.01	9.49	0.009
Manikaran Power Ltd.	0	0	8.52	0.007
Adani Enterprises Ltd.	3.69	0	5.73	0.003
GMR Energy Trading Ltd	2.32	0	5.64	0.003
NTPC Vidyut Vyapar Nigam Ltd.	13.25	0.02	4.08	0.002
Knowledge Infrastructure Systems (P) Ltd	1.5	0	2.59	0.001
Arunachal Pradesh Power Corporation (P)	0	0	2.16	0
Lanco Electric Utility Ltd	9.42	0.01	0	0
Reliance Energy Trading (P) Ltd	7.36	0.01	0.06	0

Source: Compiled from various CERC reports

Thus, it is clear from decreasing HHI that the number of licensees in the market has increased and have acquired a share reducing the size of the pie of the electricity traded by existing licensees. In 2004/05 the total number of licensees in the market was 4 and HHI was 0.55, while in 2015/16 total number of licensees increased to 27 and HHI was 0.14. It can be noticed from the figure that there is a negative relationship between HHI and the number of traders. The change can easily be traced from Fig. 4 given below.

Figure 4: Number of traders and HHI during 2004/05 to 2015/16

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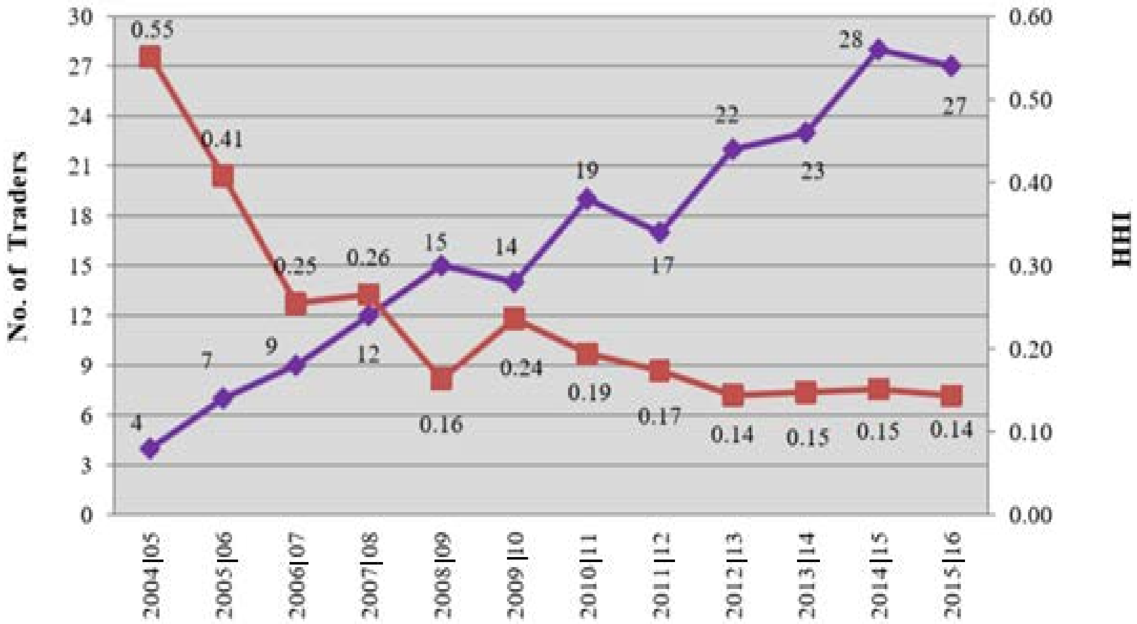

Source: CERC 2015/16

Table 3 and Table 4 shows the HHI of the ten major buyers and the sellers of electricity at the two power exchanges, i.e., IEX and PXIL. During 2015/16, the concentration of top 10 sellers of electricity in IEX is 0.027, and in PXIL it is found to be 0.19. Thus, the market power of the sellers at PXIL is high and lies into high concentration region. This is mainly due to the NDMC, Jindal Power Ltd and Jaypee Karcham Hydro Corporation Ltd which collectively sells 70 percent of the total power sold in PXIL. The monopsonistic power of the buyers at the power exchanges can also be observed by using the HHI index. The concentration of the Top 10 buyers in the IEX is 0.014 whereas in PXIL it is found to be 0.188. The monopsonistic power of the buyers in the PXIL lies in the higher concentration region which is mainly due to Uttarakhand's UPCL and IFFCO plant which collectively buys 50 percent of the total power bought in PXIL. The higher monopolistic and the monopsonistic power indicates that big firms have enough power to affect the output and price of electricity in the market which may promote illicit practices in the market.

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Table 3 : Major Buyers and Sellers at IEX and their HHI (2015/16)					
Sellers	Volume Transacted (in %)	HHI	Buyers	Volume Trasacted (in %)	HHI
JITPL	11.06	0.012	BSPHCL	6.78	0.005
GOHP	6.46	0.004	Essar Steel India Pvt Ltd	6.64	0.004
Jindal Power Ltd	5.75	0.003	WBSEDCL	3.66	0.001
Vedanta Ltd	5.17	0.003	BRPL	3.59	0.001
Adani Power Ltd	4.85	0.002	UPCL	3.24	0.001
Korba West Power Ltd	4.07	0.002	APSPDCL	3.07	0.001
TPCIL	2.96	0.001	JVVNL	2.42	0.001
Jindal steel and power Ltd	2.83	0.001	MSEDCL	2.12	0
Karcham Wangtoo HEP	2.83	0.001	Reliance Infra Ltd	2.09	0
Haryana Power Purchase Centre	2.45	0.001	KSEB	1.95	0

Source : CERC 2015/16

Table 4 : Major Buyers and Sellers at PXIL and their HHI (2015/16)					
Sellers	Volume transacted (in %)	HHI	Buyers	Volume transacted (in %)	HHI
NDMC	26.92	0.072	UPCL	37	0.137
Jindal Power Ltd.	26.88	0.072	IFFCO Plant	13	0.017
Jaypee Karcham Hydro corp. Ltd	18.83	0.035	Bodal Chemicals Ltd	12	0.014
Jindal India Thermal Power Ltd	6.92	0.005	Bhansali Engineering Ltd	11	0.012
Greenko Budhil Hydro Power(P) Ltd	4.04	0.002	Orient Abrasives	7	0.005
Gridco Ltd.	3.7	0.001	KSEB	4	0.002
MPPTCL	2.6	0.001	Oracle Granito Ltd	3	0.001
JVVNL	2.46	0.001	Jay Chemicals Ltd	2	0.000
Vedanta Ltd	2.35	0.001	City Tiles Ltd.	2	0.000
MSEDCL	2.2	0.000	Astral Poly Ltd.	2	0.000

Source : CERC 2015/16

The prices of electricity transacted through traders and power exchanges during 2008/09 to 2015/16 are shown in figure 5. The weighted average price of electricity transacted through traders and power exchanges declined from Rs 7.29/kWh and Rs 7.49/kWh respectively in 2008/09 to Rs 4.11/kWh and Rs 2.72/kWh respectively in 2015/16. The decline in the prices of the electricity traded in the short term power market shows that buyers and sellers are competing with each other to purchase/sell their desired level of electricity.

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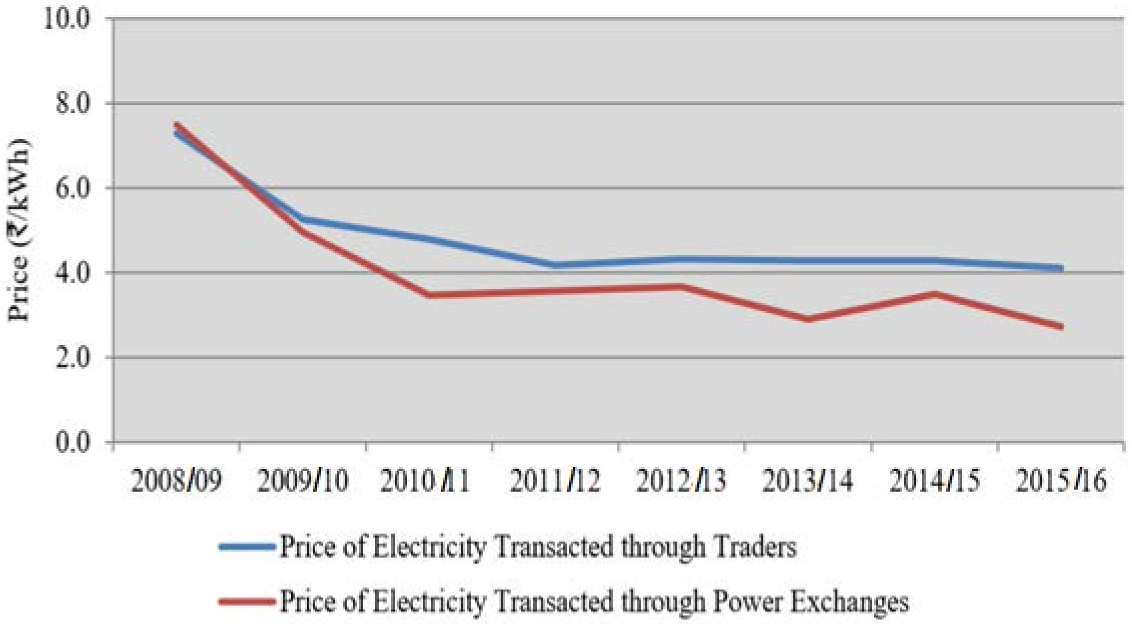
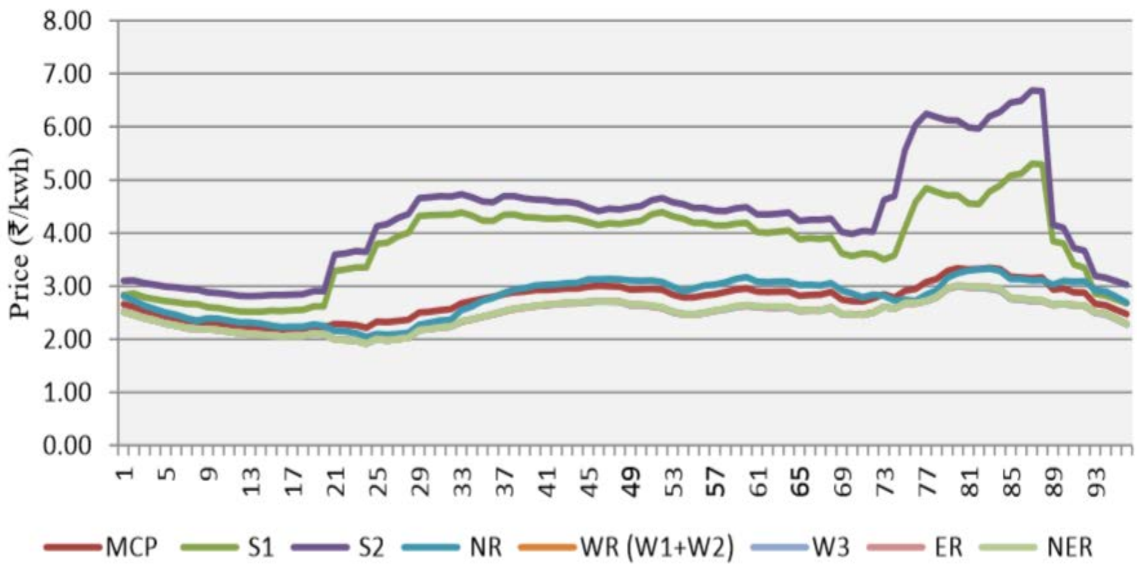
Figure 5: Price of electricity transacted through traders and power exchanges



Source: CERC 2015/16

Figure 6: Region-wise and block wise price of electricity transacted at IEX during



2015/16

Source: compiled from monthly market reports of CERC 2015/16

MCP: Market clearing price, S1: southern region 1, S2: southern region 2, NR: northern region, WR: western region, ER: eastern region, NER: northeastern region

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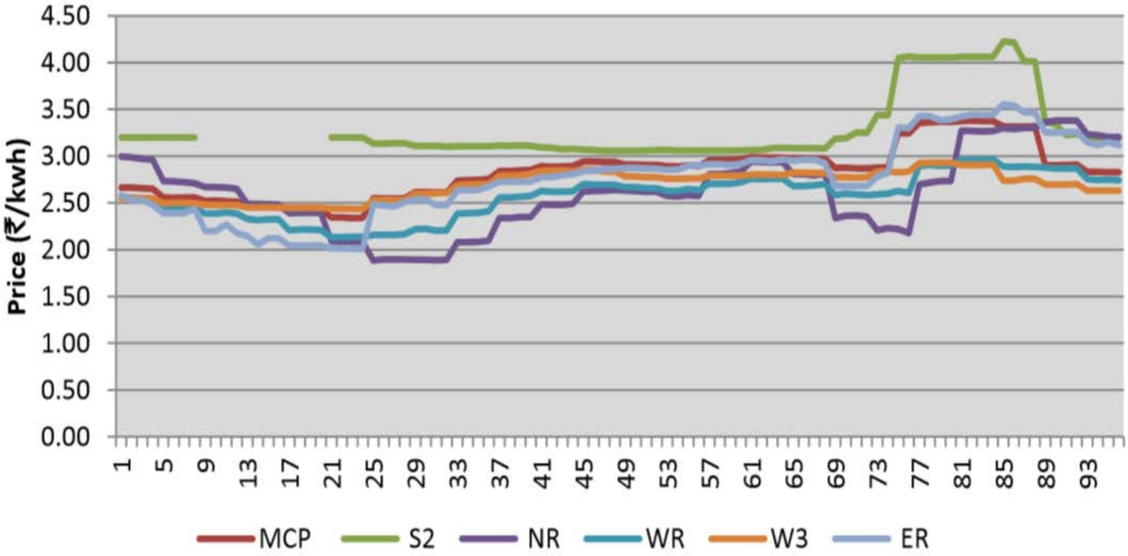
Figure 7: Region-wise and block wise price of electricity transacted at PXIL during 2015/16



Source: compiled from monthly market reports of CERC 2015/16

Figure 6 and 7 shows the hour wise and region wise prices of the electricity traded through the India Energy Exchange Ltd. (IEX) and Power Exchange of India Ltd. (PXIL). It can be observed from the figures that there is a cyclical trend in the total volume of short-term transactions of electricity. The figures show that there is no constant increase or decrease in the transactions of all segments of the short-term power market. This trend may have emerged due to seasonal fluctuations in the demand and supply of electricity. The figures also indicate that the growth of the volume of electricity differs across the regions. It can be observed from the figures that the price of electricity transacted in the Southern region (S1 and S2) was higher as compared to the prices in other regions in both the power exchanges (IEX & PXIL). This generally happens in the evening period as shown by the figures that rise in the price takes place in the evening time blocks, i.e., between 70th and 90th-time blocks. The spike in the price is mainly due to high demand which is accompanied by the increase in the congestion in the transmission line between the southern region and eastern region. This causes splitting of the markets on the power exchanges and increase in the market power of the firms in the southern region. The implication of higher price in southern region emphasizes the need to remove the bottlenecks of the transmission system especially the transmission network between eastern region and the western region so that the splitting of the markets do not occur.

5. CAUSALITY ANALYSIS OF SHORT TERM POWER MARKET IN INDIA

5.1 Methodology

The time series econometric procedures have been applied in this study to establish a cause and effect relationship for a given period. Thus, a relationship between the price is

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explained as a function of number of traders and HHI. The regression function in general can be estimated as:

Price= f (Number of traders, HHI)

Where the dependent variable is the price of electricity, and independent variables are the number of traders and HHI. The main objective of this study is to test a cause and effect relationship with the help of Autoregressive Integrated Moving Average (ARIMA) technique followed by variance decomposition. Hence other explanatory variables were not included. The estimation of the model is:

$$Price_t = \beta_0 + \beta_1 N_t + \beta_2 HHI_t + \varepsilon_t$$

where t is the time period, the dependent variable is the price, and independent variables are the number of traders and HHI and the ε_t standard error term.

In this study, the individual time series have been tested for stationarity both through graphical method, i.e., correlogram and non-graphical method of unit root test. The results for stationarity have been established by Unit Root Test by applying all the three tests Dickey-Fuller Test (DF), Augmented Dickey-Fuller Test (ADF) and the Phillips-Perron (PP). The selection of lags is also one of the most important aspects in time series econometric studies. The information criteria are the initial measures that can be adopted when selecting the appropriate lag length in a time series. However conflicting results could be found regarding the lag lengths when these criteria are used. The number of lags to be used in this study has been suggested by Akaike Information Criteria (AIC), Schwarz Criterion and the Hannan-Quinn Criterion (HQ). The selection of lag length is followed by the ARIMA which gives the regression results, followed by the construction of the Vector Autoregressive Model (VAR) to further apply the Variance Decomposition technique. The direction of causality is inferred through the Variance Decomposition technique.

5.2 Result Discussion

5.2.1. The Unit Root Test

In order to test for stationarity in the data series unit root test has been established through the Dickey-Fuller test, augmented Dickey-Fuller and further confirmed using the Phillips-Perron test. Thus, the non stationary series have been integrated by first order and further by second order wherever needed. The result of unit root test is shown in table 5. Testing the data for unit root test by DF and ADF, established the result that the HHI and price were stationary series and thus there existed no need of integrating the series to any order, also the growth rates are generally stationary. But the data set representing the number of traders weren't stationary, thus the time series were integrated for order one.

Testing for a unit root in time series was done by Dickey and Fuller (Fuller, 1976; Dickey and Fuller, 1979). The basic objective of the test is to examine the null hypothesis that $\varphi = 1$ in $y_t = \varphi y_{t-1} + u_t$ against the one-sided alternative $\varphi < 1$. Thus the hypotheses of interest are H_0: series contains a unit root versus H_1: series is stationary. The DF test is applicable only when it is assumed that u_t is a white noise error term. But if it is not white

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noise the Augmented Dickey Fuller test is applied for testing presence of unit root. Thus, the test is augmented using p lags of the dependent variable.

$$\Delta y_t = \psi y_{t-1} + \sum^{p}_{i=1} \alpha_i \Delta y_{t-i} + u_t$$

The lags of Δy_t now ensure that u_t is white noise error term. The test is known as an augmented Dickey Fuller (ADF) test and is still conducted on ψ, and the same critical values from the DF tables are used as before. Table 5 shows the results of the three tests of unit root the ADF, DF and Phillip-Perron test such that the HHI and price series are originally stationary, but the number of traders is non stationary series.

Table 5: Unit Root Test

Variables	DF	ADF	PP
HHI	-0.74	-3.6	-8.6
Price of Electricity Transacted through Trading licensees (Rs/kWh)	-2.6	-3.01	-.6.9
No. of Traders	-8.4	-7.1	-9.7

Note: The critical values at 1percent, 5percent and 10 percent level of significance is -3.6, -2.9 and -2.6 percent respectively.

Source: EViews 8 output

5.2.2. Variance Decomposition

When changes in one variable affect the autoregressive process of all the other dependent variables, then the VAR model provides a multivariate framework for it. Variance decomposition functions demonstrate how each factor contributes to the changes in the price of the electricity. A vector autoregressive model of order p can be seen as:

$$R_t = C_0 + \sum^{p}_{i=1} \Phi_i R_{t-I} + \psi D_t + u_t ,$$

where t = 1,2,….,n.

When annual data is available, then variance decomposition compares the variables year by year, thus period wise results are obtained. The additive form of the decomposition is:

$$P = \sum_i \sum_j N_i H_j$$

where P is the price of electricity, N_i is the number of traders and H_j is the HHI index.

Table 6 represents the variance decomposition between the price of electricity and the number of traders. It is observed that both in the short run and long run that is in the entire time horizon the shocks in prices of electricity are explained upto 75 percent by the shocks or changes in the number of traders. Most of the shock effect in prices of electricity is explained by number of traders that is upto 74 percent in the short run and 76 percent in the long run of its shocks. Rather in the second table, the variation in the number of

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traders is explained by prices of electricity to an extend of 1 percent both in the short run and long run.

Table 6: Variance decomposition of Price of electricity and Number of traders

Variance Decomposition of Price of electricity			
Period	S.E.	Number of Traders	Price of Electricity
1	0.168400	74.44694	25.55306
2	0.176542	75.51374	24.48626
3	0.180674	76.15050	23.84950
4	0.182525	76.42377	23.57623
5	0.183359	76.54413	23.45587
6	0.183736	76.59799	23.40201
7	0.183906	76.62227	23.37773
8	0.183983	76.63325	23.36675
9	0.184018	76.63822	23.36178
10	0.184034	76.64047	23.35953
Variance Decomposition of Number of Traders			
Period	S.E.	Number of Traders	Price of Electricity
1	3.286106	100.0000	0.000000
2	3.447248	99.17831	0.821692
3	3.513328	98.82654	1.173456
4	3.542820	98.67514	1.324863
5	3.556112	98.60812	1.391882
6	3.562123	98.57806	1.421942
7	3.564845	98.56449	1.435507
8	3.566078	98.55836	1.441644
9	3.566638	98.55558	1.444424
10	3.566891	98.55432	1.445684

This shows that the shocks in prices of electricity are explained around 1.5 percent by the shocks or changes in the HHI. Most of the shock effect in prices of electricity is explained by number of traders. Rather in the second table, the variation in the HHI is explained by prices of electricity to the extent of 13 percent both in the short run and long run. This shows that the shocks in the price of electricity are hardly explained by the changes in the HHI. This is a weak explanatory model compared to the model by prices and the number of traders.

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Table 7: Variance decomposition of Price of electricity and HHI

Variance Decomposition of HHI			
Period	S.E.	HHI	Price of Electricity
1	0.003327	100.0000	0.000000
2	0.009536	13.51764	86.48236
3	0.009803	13.31140	86.68860
4	0.009953	13.01468	86.98532
5	0.009979	12.97665	87.02335
6	0.009987	12.96267	87.03733
7	0.009989	12.95971	87.04029
8	0.009989	12.95888	87.04112
9	0.009989	12.95868	87.04132
10	0.009989	12.95863	87.04137
Variance Decomposition of Price of Electricity			
Period	S.E.	HHI	Price of Electricity
1	0.200156	1.068060	98.93194
2	0.204141	1.531034	98.46897
3	0.207267	1.576209	98.42379
4	0.207736	1.596365	98.40363
5	0.207895	1.600297	98.39970
6	0.207930	1.601451	98.39855
7	0.207939	1.601724	98.39828
8	0.207942	1.601797	98.39820
9	0.207942	1.601815	98.39819
10	0.207942	1.601819	98.39818

The result of the regression of the prices on the number of traders and HHI is reflected in table 8.

Table 8: Regression Results

Dependent Variable : Prices of Electricity			
Regressors	**Coefficients**	**t-Values**	**Probability**
N	0.016899	0.627135	0.5646
HHI	13.83358	3.286366	0.0303
C	1.762868	1.425487	0.2272

Source: EViews 8 output

The result of the Autoregressive Integrated Moving Average (ARIMA) model is such that there exists a positive relationship between the price of electricity and the number of traders and HHI, i.e., higher the number of traders and HHI, higher the prices. According to this regression model, the variable of HHI is statistically significant, but the number of

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traders is not which is in contradiction to the results of the variance decomposition model. The R square of this ARIMA is 0.86 and an adjusted R square of 0.79 which represents a loosely fitted model.

6. CONCLUSION

In the present analysis of the competition in the short term power market in India, the standard measures of the competition suggest that the motive of the Indian Electricity Act, 2003, i.e., to promote competition in the power sector is going in the right direction. Increase in the competition means a decrease in the prices, large number of suppliers and buyers, reduction in the transaction cost and freedom to set prices, decrease in the market power of firms. According to the variance decomposition under the VAR model, the shocks in the price of electricity is chiefly explained by the changes in number of traders rather than by the HHI index. However, the regression results show HHI as a significant variable but not number of traders. The regression coefficients of HHI show a positive relationship such that if HHI decreases the price of electricity also decreases. This shows that the competition has increased in the market. The short term power market has seen fall in the market power of the traders, increase in the number of buyers and sellers in the market and decrease in the prices. The transmission congestion has likely impact on the market power of the firms. Holding physical transmission rights can increase the market power of a seller in the importing region which reduces the imports of cheaper power from the exporting region. The inter-regional transmission capacity in India is insufficient for the transfer of power between the regions. This calls for the improvement in the transmission system especially between the southern and the other regions. To conclude, in the absence of adequate integration of the national grid, the spirit of the Indian Electricity Act, 2003 to increase the competition and efficiency in the Indian power sector will be defeated. This also explains that despite the fact that nearly ten years have passed since the inception of the power exchanges in 2008, the volume of short term power market has remained stuck to 9-11 percent of the total electricity generated in India, which is far too less when compared to the other nations of the West.

APPENDIX

I Regression result

Dependent Variable: PRICE
Method: Least Squares
Date: 02/14/18 Time: 08:52
Sample: 1 7
Included observations: 7

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DNO	0.016899	0.026946	0.627135	0.5646
HHI	13.83358	4.209387	3.286366	0.0303

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C	1.762868	1.236678	1.425487	0.2272

R-squared	0.864123	Mean dependent var	4.462857
Adjusted R-squared	0.796185	S.D. dependent var	0.413913
S.E. of regression	0.186865	Akaike info criterion	-0.219338
Sum squared resid	0.139673	Schwarz criterion	-0.242520
Log likelihood	3.767685	Hannan-Quinn criter.	-0.505856
F-statistic	12.71923	Durbin-Watson stat	2.446549
Prob(F-statistic)	0.018462		

II Variance Decomposition of Price of electricity and No. of traders

Variance Decomposition DNO: Period	S.E.	DNO	PRICE
1	3.286106	100.0000	0.000000
2	3.447248	99.17831	0.821692
3	3.513328	98.82654	1.173456
4	3.542820	98.67514	1.324863
5	3.556112	98.60812	1.391882
6	3.562123	98.57806	1.421942
7	3.564845	98.56449	1.435507
8	3.566078	98.55836	1.441644
9	3.566638	98.55558	1.444424
10	3.566891	98.55432	1.445684
Variance Decomposition of PRICE: Period	S.E.	DNO	PRICE
1	0.168400	74.44694	25.55306
2	0.176542	75.51374	24.48626
3	0.180674	76.15050	23.84950
4	0.182525	76.42377	23.57623
5	0.183359	76.54413	23.45587
6	0.183736	76.59799	23.40201
7	0.183906	76.62227	23.37773
8	0.183983	76.63325	23.36675
9	0.184018	76.63822	23.36178
10	0.184034	76.64047	23.35953
Cholesky Ordering : DNO PRICE			

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III Variance decomposition of HHI and Price of electricity

Variance Decomposition of HHI:			
Period	S.E.	HHI	PRICE
1	0.003327	100.0000	0.000000
2	0.009536	13.51764	86.48236
3	0.009803	13.31140	86.68860
4	0.009953	13.01468	86.98532
5	0.009979	12.97665	87.02335
6	0.009987	12.96267	87.03733
7	0.009989	12.95971	87.04029
8	0.009989	12.95888	87.04112
9	0.009989	12.95868	87.04132
10	0.009989	12.95863	87.04137
Variance Decomposition of PRICE:			
Period	S.E.	HHI	PRICE
1	0.200156	1.068060	98.93194
2	0.204141	1.531034	98.46897
3	0.207267	1.576209	98.42379
4	0.207736	1.596365	98.40363
5	0.207895	1.600297	98.39970
6	0.207930	1.601451	98.39855
7	0.207939	1.601724	98.39828
8	0.207942	1.601797	98.39820
9	0.207942	1.601815	98.39819
10	0.207942	1.601819	98.39818
Cholesky Ordering: HHI PRICE			

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REFERENCES

[1] Ahmad M. I. (2017), "Seasonal Decomposition of Electricity Consumption Data", *Review of Integrative Business and Economics Research*, Vol. 6(4), 271-275.

[2] Central Electricity Regulatory Commission, (2010), *Annual Report—short-term power market in India*, /http://www.cercind.gov.in.

[3] Central Electricity Regulatory Commission, (2016), *Annual Report—short-term power market in India*, /http://www.cercind.gov.in.

[4] Dipti Sharma (2015), "Changing Scenario of Indian Electricity Supply Industry: Study of Short-Term Power Market in India", *Energy Security and Development—The Global Context and Indian Perspectives*, Springer India 2015, 349-360.

[5] Hunt, Sally, et al. (1997), "Introduction: economic and technological principles in designing power markets", In Hunt, S., Shuttleworth, G. (Eds.), Competition and Choice in Electricity. *John Wiley & Sons Ltd*., West Sussex, England, 1–10.

[6] Joskow, Paul, (2003), "Electricity sector restructuring and competition: Lessons learned", *Cuadernos de Economía*, *Año* 40, No. 121, Latin American and U.S. Universities: A Forty Year Analysis, 548-558.

[7] Lerner, A.P., (1934), "The concept of monopoly and the measurement of monopoly power", *Review of Economic Studies*, 1, 157–175.

[8] Robinson, Terry & Baniak, Andrej, (2002), "The volatility of prices in the English and Welsh electricity pool", *Applied Economics*, Vol. 34(12), 1487-1495.

[9] S. Prabhakar, Raglend & Kothari, (2013). "A review on market power in deregulated electricity market", *Electrical Power and Energy Systems*, 48, 139–147.

[10] Shukla, U.K & Thampy, A. (2011), "Analysis of competition and market power in the wholesale electricity market in India", *Energy Policy*, Vol. 39, 2699–2710.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)