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# **Empirical Analysis of Developments in the Day Ahead Electricity Markets in India**

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## **Abstract**

Given the thrust on the deregulation of electricity markets in India since 2003, the short term electricity market with power exchanges in particular have evolved rapidly to support the growth of the power markets in an efficient manner. Since their year of inception 2008, power exchanges are now more efficient and are able to mitigate risks arising from price volatility for the participants to a large extent. This paper throws light on the trading of day ahead electricity contracts in India. We try to assess whether day ahead electricity returns and return volatility exhibit weekday effect. The study also looks at the effect of traded volume of electricity on electricity return volatility and the impact of introduction of the fifteen minute contracts in the day ahead electricity market in India on returns and return volatility.

**Keywords: Power trading, electricity futures, Power exchange**

**JEL Codes: Q41, Q48, D44**

## **1. Introduction**

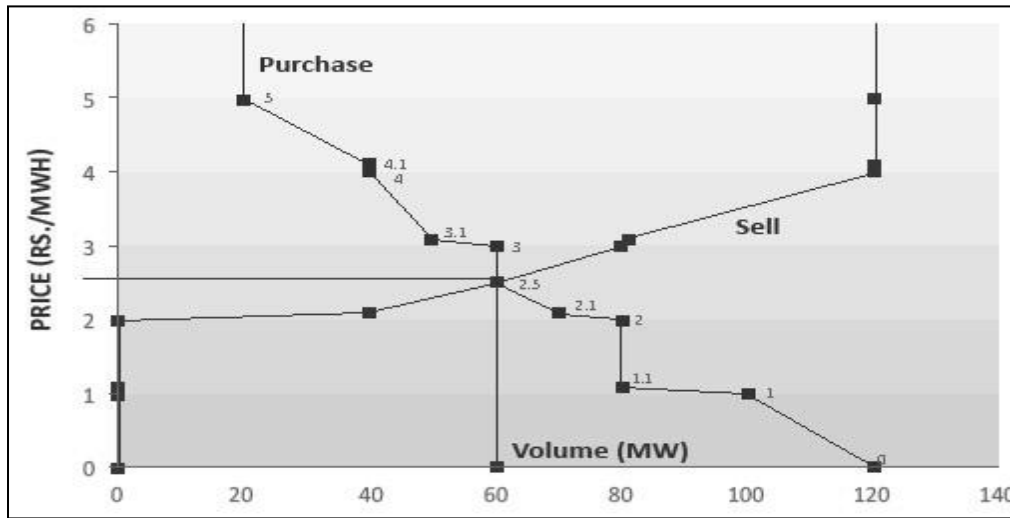
Electricity is a tradable commodity and has a typical characteristic of being non-storable, and it must be consumed once it is produced. It is one of the 113 commodities notified by FCRA (1952), but it is currently not traded on national commodity exchanges and not regulated by SEBI (earlier FMC). Trading in electricity is regulated by the Central Electricity Regulatory Commission (CERC). Electricity is transacted in the form of long term as well as short term contracts in India. Long term contracts are generally bilateral contracts with duration of the contract ranging from 12 years to 25 years, while the duration of short term contracts normally varies between 15 minutes to 3 years. The short term trading of electricity is expected to meet the unplanned requirements of buyers and enable producers of electricity to sell surplus power as electricity is a non-storable commodity. Short term electricity markets help in improving the reliability of the systems by taking care of intermediate load requirements.

In the day ahead market, a price contract for electricity is determined on a day and deliver on the following day, for example, price and volume for a contract are determined on Monday and the contract is delivered on Tuesday. Within the day ahead electricity market, out of the two power exchanges (Indian Energy Exchange, IEX and Power Exchange of India Limited, PXIL) operating in India, IEX is the dominant player. Thus, we discuss the process of day ahead electricity contracts as traded on IEX in detail.

IEX has been involved in day ahead trading of electricity since 2008 and is a physical delivery based market. For the day ahead market, IEX offers a double side close auction for delivery on the next day. The power exchange receives offers from producers for the provision of electricity and their minimum selling price. Similarly, retailers submit bids to the power exchange for consumption of electricity and the maximum price they would be willing to buy it at. Bids for 96 blocks of 15 minutes each can be entered. The bids are accumulated by IEX from 10am to 12 noon. The bids entered between 10am and 12 noon can be revised or cancelled only till 12 noon.

At the end of the bidding session, the exchange utilises an algorithm to determine the market clearing price, production and consumption schedule for each hour of the market horizon. The aggregate supply and demand curves are drawn on Price Quantity axes. The intersection point of the supply and demand curves determines the Market Clearing Price (MCP) and Market Clearing

Volume (MCV). Prices are reported in Rs/Mega Watt hour. Bids are matched for each 15 minute block (See Figure 1).

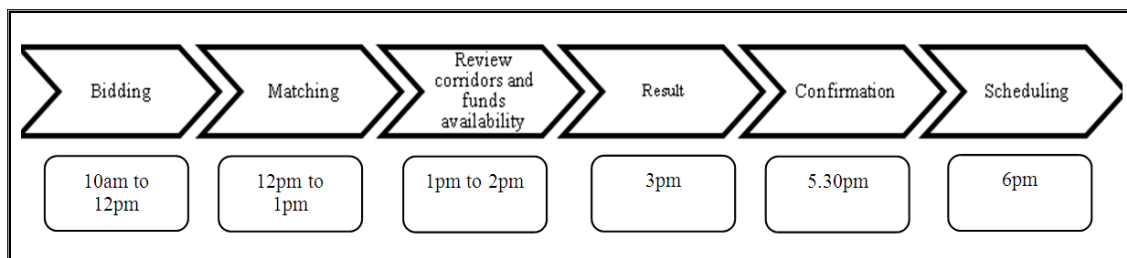


Source: IEX

**Figure 1: Demand Supply graph utilized for determining MCP and MCV**

After the prices are determined, members of the exchange whose bids have been executed fully or partially are provided the information regarding the contract traded. On the basis of the market clearing price and volume, IEX gives an unconstrained scenario of the day ahead market.

After checking of settlement funds of members and requisite capacity with the National Load Dispatch Centre (NLDC), fresh iterations are run at 2.30 pm, after which the final market clearing price and volumes are determined by the power exchange. In case there is congestion, the market is split and the members in different bid areas end up paying different prices. On receipt of the final results, obligations are sent to banks for payment for the consumption bids of retailers. This is followed by sending of final results for confirmation and applications of collective transactions are sent to NLDC. A scheduled transaction is considered to be deemed for delivery on the following day. The entire Day Ahead Market Trading process used at IEX is described in Figure 2.



Source: IEX

**Figure 2: The Day Ahead Market Trading Process at IEX**

The exchange has divided its operations into 12 bid areas (see Table 1). The minimum bid allowed on IEX is Re.1 for 0.1 MWh. The two types of bids allowed on IEX include single order bids and block orders. Single bids are fifteen minute bids for different pairs of price and quantity, partial execution of the entered bids by participants is possible whereas Block Orders include a series of fifteen minute blocks during the same day but there is no provision of partial execution in block orders at IEX.

**Table 1: IEX Bid Areas**

S.No	Bid Area	Region	States covered under the Bid Area
1	N1	North Region	Jammu and Kashmir, Himachal Pradesh, Chandigarh, Haryana
2	N2	North Region	Uttar Pradesh , Uttaranchal, Rajasthan, Delhi
3	N3	North Region	Punjab
4	E1	East Region	West Bengal, Sikkim, Bihar, Jharkhand
5	E2	East Region	Orissa
6	W1	West Region	Madhya Pradesh
7	W2	West Region	Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa
8	W3	West Region	Chhattisgarh
9	S1	South Region	Andhra Pradesh, Karnataka, Pondicherry (Yanam), South Goa
10	S2	South Region	Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe)
11	A1	North East Region	Tripura, Meghalaya, Manipur, Mizoram, Nagaland
12	A2	North East Region	Assam, Arunachal Pradesh

Source: IEX

Table 2 shows details of bids received annually for buying and selling from each of the 12 bid areas from 2008-09 to 2013-14.

**Table 2: Yearly volume in the twelve bid areas of IEX (2008-09 to 2013-14) (in MWh)**

Bid Areas	Years	2008 - 09	2009 – 10	2010 – 11	2011 – 12	2012 - 13	2013 – 14
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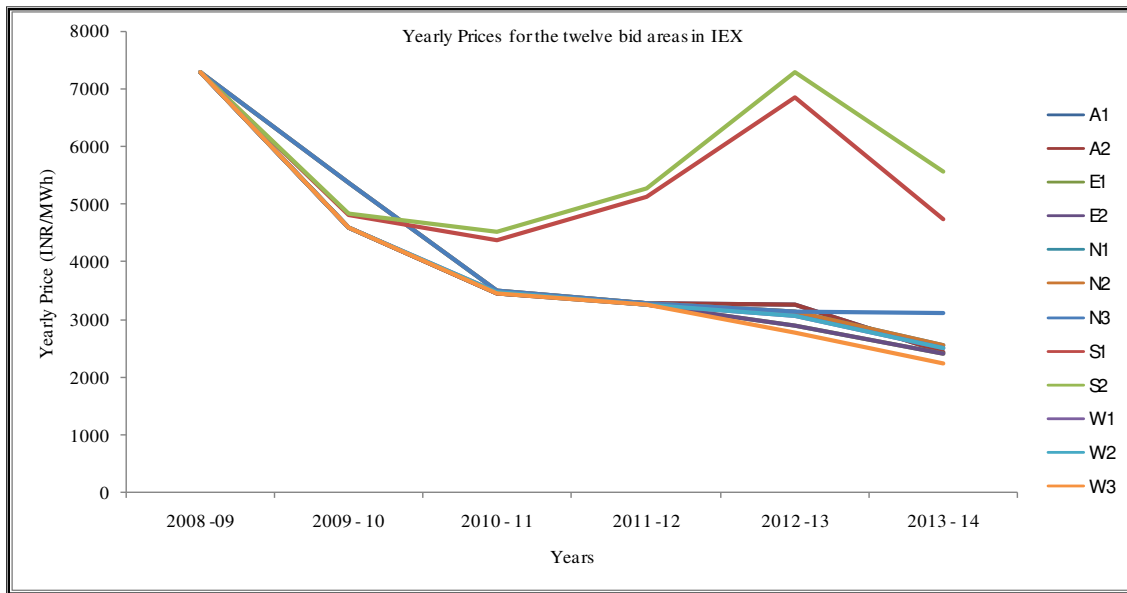
<b>A1</b>	Buy	2902.38	61034.08	23643.01	8827.8	82440.29	126022.54
	Sell	87178.87	76124.57	234977.50	232922.61	171300.72	415909.89
<b>A2</b>	Buy	200.00	25705.24	41182.17	215756.79	313222.75	291912.31
	Sell	48460.41	11049.27	144372.42	174732.4	108538.03	298443.03
<b>E1</b>	Buy	1178.07	28678.64	136012.50	518873.13	442593.66	824371.77
	Sell	566726.27	711742.11	1130818.09	1214620.1	1229323.1	2251678.6
<b>E2</b>	Buy	484.50	25192.25	210.19	81996.88	35509.65	81779.68
	Sell	27355.87	26405.48	173711.57	327668.77	307737.73	1293793.6
<b>N1</b>	Buy	110193.36	540053.47	3514773.68	2227133.5	1417912	2475280.7
	Sell	437767.83	450971.28	913377.50	2169421	4372785	5378394.7
<b>N2</b>	Buy	57557.25	2696358.62	2691173.16	2383627.2	5648411.5	6401146.7
	Sell	477931.46	639286.04	2381395.12	2413119.9	3646381.3	4269449.2
<b>N3</b>	Buy	-	-	-	1656991.7	2794005.1	2381974
	Sell	-	-	-	190234.56	39061.36	122281.63
<b>S1</b>	Buy	981966.47	555730.69	460979.59	1100288.5	2034858.9	3631882.5
	Sell	63687.56	1067563.91	1488835.04	1266638.3	3814424.1	2917368.2
<b>S2</b>	Buy	647055.83	1341100.98	2827247.34	2340879.7	2474069.8	997036.87
	Sell	1339.11	19251.14	23075.75	5559.17	661.82	325427.93
<b>W1</b>	Buy	127339.87	472.43	135033.19	567659.22	426531.47	459732.88
	Sell	646707.55	2081824.87	2504331.54	1097492.1	1432092.3	2810881.4
<b>W2</b>	Buy	687331.05	896611.38	1970323.89	2690599.5	6627307.3	10693517
	Sell	261508.07	1086719.11	2805684.19	3436981.5	2936003.9	5277812.1
<b>W3</b>	Buy	-	-	-	5466.76	77970.02	560234.83
	Sell	-	-	-	1268645.5	4316513.4	3563445

Source: IEX

The table above clearly indicates that there has been a rise in the number of bids in most of the bid areas over the period. In terms of volume (mean volume over years), bid area W2 (Maharashtra, Gujarat, Daman and Diu, Dadar and Nagar Haveli, North Goa) and bid area N2 (Uttar Pradesh, Uttaranchal, Rajasthan, Delhi) are found to be leading.

Participants from various sectors were involved in trading of electricity through day ahead market at the power exchange, these included: captive power plants, industrial consumers owning captive power plants, industrial consumers, independent power producers, state utilities and private distribution licensees. At the end of March 2014, 2958 Open Access Consumers were purchasing power and procured 17575 MU of electricity from IEX in 2013-14.

Moving on to prices, Figure 3 illustrates the yearly price of power available for the 12 bid areas via day ahead trading at IEX.



Source: IEX

**Figure 3: Yearly prices of power for bid areas in IEX (INR/MWh)**

The figure above clearly suggests that the prices in bid area S1 (Andhra Pradesh, Karnataka, Pondicherry (Yanam), South Goa) and bid area S2 (Tamil Nadu, Kerala, Pondicherry (Puducherry), Pondicherry (Karaikal), Pondicherry (Mahe)) remained on the higher side compared to other bid areas. This could be attributed to the higher demand for electricity in the Southern Region and unavailability of transmission corridor in these regions due to constraints on the Southern grid in the second quarter of 2013. The most active bid area is found to be W2, the current study describes the movement of day ahead prices of electricity traded in the W2 bid area.

The current study is divided into five parts, while the first section (i.e., Introduction) discusses the operation of day ahead electricity market, the Section 2 of the paper reviews the literature related to short term electricity contracts with special reference to day ahead electricity contracts traded on power exchanges. Section 3 discusses the data and methodology used for analysing the presence of the weekday effect on return and volatility of electricity, effect of traded volume on volatility of electricity and the impact of introduction of fifteen minute contracts by the power exchange. Section 4 reports the empirical results while Section 5 concludes the paper.

## 2 Literature Review

A review of the existing literature indicates the application of various techniques to study the day ahead electricity prices across a number of electricity exchanges in the world.<sup>1</sup> While some studies analyse the day ahead hourly prices and the forecasting of prices, a number of studies focus on trading volume and volatility of spot and day ahead electricity contracts.

Huisman et al. (2007) study the hourly day ahead electricity prices of three power exchanges (Amsterdam Power Exchange, European Energy Exchange, Purchase Power Exchange of Paris) in a panel framework. They find that hourly electricity prices in a day ahead market mean revert around a specific mean price level and the speed of the mean reversion of prices varies across hours. A cross correlation matrix is also constructed by the authors which shows a peak – off peak correlation structure, prices in peak hours are found to be strongly correlated among each other and the same is valid for trading in off peak hours. Longstaff and Wang (2004) study the hourly day ahead and spot electricity prices of PJM market and find a significant forward premia in forward electricity prices.

A review of the various methodologies used to forecast electricity prices is extensively discussed in the paper by Aggarwal et al. (2009). The study categorises price forecasting methodologies into three variants: univariate linear models (ARIMA), multivariate linear models (Dynamic Regression, Transfer Function) and non linear models (Artificial Neural Network).

Many studies attempt to forecast future prices of day ahead electricity contracts. Zhou et al. (2006) perform the forecasting of hourly electricity prices of Californian Power Market. ARIMA model and extended ARIMA model approach through successive error correction are the two methods employed by the authors for forecasting. The authors find that the error correction method with ARIMA model for price forecasting improves the accuracy of the forecasts.

Conejo et al. (2005) predict the market clearing prices using data of PJM Interconnection of the year 2002 employing the ARIMA, dynamic regression and transfer function models. The study concludes that among the techniques, dynamic regression and transfer function algorithms are more effective than ARIMA models. For Spain and California day ahead electricity markets,

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<sup>1</sup> A note on Power Exchanges – an International Experience is given in Appendix A5.



Contreras et al. (2003) use Auto Regressive Integrated Moving Average (ARIMA) technique to forecast day ahead electricity prices.

Another study which uses time series models to forecast daily electricity prices is by Bowden and Payne (2008). The models employed include ARIMA, ARIMA-EGARCH, ARIMA-EGARCH-M model. The authors apply the models to hourly real time location based marginal prices for five hubs of Midwest Independent System Operator for the period from 9 July 2007 to 6 August 2007. The study concludes that neither of the models dominate the other in terms of insample forecasting performance, whereas ARIMA EGARCH-M model is found to outperform the other models when analysed in terms of outsample forecasting performance.

Authors employ time series models including AR, MA, ARMA and ARIMA models to forecast electricity prices. Jakasa (2011) applies the ARIMA model to forecast the day ahead spot electricity of prices of German Electricity Market for the period from 2000-2011. Different specifications of the ARMA methodology are employed by Cuaresma et al. (2004) to forecast the electricity spot prices of Leipzig Power Exchange. The authors use the sample period between June 2000 and October 2001. The different specifications include AR(1) process with time varying intercept, ARIMA process with time varying intercept, ARMA processes with jumps, and unobserved components model. Using the measures of forecast, Root Mean Square Error (RMSE) and Mean Absolute Error (MAE), the authors conclude that the separable crossed ARMA model with jumps and restricted coefficient depict high accuracy in forecasting. Kristiansen (2012) focuses on forecasting of electricity day ahead prices using autoregressive exogenous (ARX) model with exogenous variables and compute the price predictions for Nord Pool electricity prices.

The GARCH technique is employed by Guirguis and Felder (2004) to forecast the electricity prices of regions of New York – New York City and Central New York State. The GARCH technique forecasts are contrasted with dynamic regression technique, transfer function models as well as exponential smoothing. They also examine the volatility of electricity prices as an ARCH process and GARCH-M process, and also account for unusually high values of electricity prices. The authors find that the GARCH process is substantially better than dynamic regression technique, transfer function models as well as exponential smoothing. The same methodology is

applied by Garcia and Contreras (2005) to forecast the day ahead electricity prices of Spanish and California electricity markets. The authors make a comparison of the forecasts obtained from GARCH with forecasts of ARIMA methodology for the two markets and find GARCH methodology outperforms the ARIMA Model.

Studies use variants of GARCH model to forecast short term electricity prices. One of the studies by Liu and Shi (2013) models and forecasts electricity day ahead prices of ISO New England market. The time period of their study is 1 January 2008 to 28 February 2010 using variants of ARMA- GARCH in mean models which include – ARMA-QGARCH in mean model, ARMA-SGARCH in mean model, ARMA-GJRGARCH in mean model, ARMA-EGARCH in mean model, ARMA-NGARCH in mean model. The study concludes that ARMA-GARCH in mean models are more accurate than ARMA-GARCH models.

While some studies employ time series techniques, some prefer newer techniques which include transfer function models, wavelet transformation, etc. Nogales et al. (2002) use dynamic regression and transfer function models to predict the electricity power prices of Spanish market and California. The authors carry out the study for a low demand week as well as high demand week for the Spanish Electricity market to validate the performance of the proposed model. The authors find that the Spanish market is more volatile than the California market due to lesser competition.

A Markov Switching generalised autoregressive conditional heteroskedasticity (MS-GARCH) model is applied to the daily electricity prices of Nordic Electric Power Market by Cifter (2013) for studying the electricity price volatility. The author also employs other conditional volatility models which include GARCH model, and GJR (p,q) model. The results clearly indicate that MS-GARCH model is more accurate than other models and the volatility of prices of Nordic Electric Power Market is found to be highly volatile while being dependent on regime.

Raviv et al. (2013) employ dynamic AR Model, Heterogeneous Autoregressive model, VAR Model, Bayesian VAR Model as well as Factor Models to study the hourly prices of electricity traded in Nord Pool Spot Market during the period from 1992-2010. The accuracy of the forecasts is estimated by comparison of means of the root mean squared error (RMSE), the mean absolute error (MAE), and the mean absolute percent error (MAPE). They conclude that

dimension reduction techniques fare better than univariate forecast method in terms of forecast accuracy.

Singhal and Swarup (2011) use artificial neural networks to forecast electricity prices with a three layer back propagation network. They use hourly market clearing prices for the study. It is found from the results of neural networks that the price of electricity in deregulated markets is a factor of load demand as well as the clearing price. Tan et al. (2010) study the Spanish and PJM electricity markets with a method based on wavelet transformation combined with ARIMA and GARCH models to predict the future value of series. The predictions derived are then compared to ARIMA, ARIMA-GARCH, and WT-ARIMA models by the authors.

Li et al. (2007) propose fuzzy interference system, least square estimation and a combination of the two techniques for day ahead electricity price forecasting. The data tested belongs to the Pennsylvania-New Jersey-Maryland (PJM) market of the US for the sample period between January and December 2004. To evaluate the results derived from forecasting, the authors calculate root mean square error (RMSE) and mean absolute percentage error (MAPE). The models suggested by the author are found to be performing more efficiently in comparison to neural networks, ARMA and GARCH.

Some studies employ non linear models including neural network model to forecast electricity prices. Catalao et al. (2007) propose a neural network approach to forecast the next week electricity prices of mainland Spain and California electricity market. The accuracy of forecasted value is checked with mean absolute percentage error – MAPE criterion, the sum squared error – SSE criterion, and the standard deviation of error – SDE criterion. The accuracy from neural network forecasted price is compared with that of ARIMA technique. The authors find that the neural network approach outperforms the ARIMA technique. Using the day ahead electricity prices of PJM and Spanish market, Zhang and Tan (2013) employ the Wavelet transformation technique, Chaotic least square support vector machine and EGARCH for the purpose of forecasting prices. A hybrid approach including the three techniques is used for the study by the authors. They find that hybrid model is superior to other models taken individually.

A number of studies have provided an analysis of the impact of trading volume on the volatility in price of electricity contracts (futures as well as spot). Trading volume and volatility in price of

electricity futures traded in New York Mercantile Exchange (NYMEX) are examined by Hadsell (2006) for the period from March 1996 to December 1999 using a TARARCH specification. Near month contract prices for four markets (California-Oregon Border, Palo Verde Switchyard in Arizona, Cinergy and South Eastern states) are used in the study. Currently, volume is found to be significantly affecting the volatility in prices for two (California-Oregon Border, Palo Verde Switchyard in Arizona) out of the four markets, while Lagged Volume are also found to be significant for the two markets.

A study by Higgs and Worthington (2005) discusses four regional markets (New South Wales, Queensland, South Australia and Victoria) in the Australian Electricity market and finds that there is a presence of mean spillover effect of their own price respectively. A positive relationship is observed between price volatility and volume of demand in the four markets. The authors conclude that a higher volatility is seen to persist in case of Monday; peak summers and peak winter months.

Fontana et al. (2007) present a study based on a GARCH model to analyse the impact of volumes on the spot prices associated with four electricity markets (European Electricity Exchange, PowerNext, Omel and APX). The authors find that the impact of volume of electricity traded is insignificant for three of the four markets and a positive relation between volatility and volume in case of Spain. A similar study is carried out by Gianfreda (2010) for electricity markets of Germany, France, Spain, Netherlands, and Italy. The author uses three variants of GARCH model to study seasonality and impact of volume on volatility – SEGARCH model (seasonality), VEGARCH (volume) and SVEGARCH model (seasonality and volume). It is found that traded volume affects volatility negatively in case of Germany, France, Spain and Italy, whereas it is found to be positive in case of Netherlands.

Some studies have also discussed other aspects related to electricity prices, these include – impact of electricity futures on spot price volatility, impact of congestion on volatility, forecasting of electricity load and seasonality in electricity spot prices. The impact of introduction of futures contracts on electricity on the spot price volatility of two electricity markets (Powernext and European Electricity Exchange) is studied by Kalantzis and Milonas (2013) with the help of a bivariate VECM-GARCH model. They find that the introduction of

electricity futures has led to a decline in the spot price volatility in Powernext and the effect was not strong in case of European Electricity Exchange. Fan and Hyndman (2011) employ semiparametric additive models to estimate the electricity demand for half hour electricity contracts of the Victorian Region of Australian National Electricity Market.

GARCH models are employed by Hadsell and Shawky (2006) to provide the volatility characteristics of the day ahead and spot electricity market of New York State Independent Systems Operator for peak hours. Tests conducted by the authors are found to reveal that the volatility persistence in day ahead market is higher than the volatility persistence in spot markets. The authors also measure the effect of congestion on the volatility of spot market using lagged values of marginal cost of congestion and conclude that a lower congestion is associated with reduced volatility.

Thomas et al. (2011) observe the patterns of seasonality in the electricity spot prices of Australian National Electricity market during the period from January 1999 to January 2006. The authors discuss that out of the weekdays, Monday, Tuesday and Wednesday contribute more to the return of half hourly price than other days while no clear pattern is seen for months. Some prices are found to be negative in non peak hours and have a negative effect in returns.

### **3 Data and Methodology**

The current study focuses on the hourly day ahead prices and volume of W2 bid area of Indian Energy Exchange (IEX). Fifteen minute day ahead electricity contracts were introduced and delivered on 1 April 2012. The period of study is 1 April 2010 to 31 March 2014, i.e., two years prior to 1 April 2012 and two years after 1 April 2012). The data for this study was downloaded from IEX Website. Hourly settlement of day ahead prices (area clearing price) and trading volume (area clearing volume purchased after transmission congestion) were obtained from the IEX website. Each hour was taken separately for analysis. Therefore, a single time series is used for each hour for the period of study. Table 3 provides summary statistics for the hourly day ahead prices and volume cleared in W2 bid area (highest volume among bid areas) for the period from April 1, 2010 to March 31, 2012.

**Table 3: Summary Statistics of Electricity purchased in W2 Bid Area (April 1, 2010 to March 31, 2012)**

<b>Hours</b>	<b>Parameter</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Standard Deviation</b>
<b>00-01</b>	<b>Price</b>	749.19	8700.49	2751.75	1275.48
	<b>Volume</b>	4.90	1410.00	192.60	191.57
<b>01-02</b>	<b>Price</b>	749.13	8700.14	2584.12	1151.89
	<b>Volume</b>	11.70	1429.90	164.87	173.01
<b>02-03</b>	<b>Price</b>	749.15	8000.30	2452.77	997.79
	<b>Volume</b>	11.70	1420.00	154.07	171.48
<b>03-04</b>	<b>Price</b>	749.10	8000.02	2394.43	968.47
	<b>Volume</b>	11.70	1420.00	144.75	167.99
<b>04-05</b>	<b>Price</b>	749.09	7597.35	2423.13	908.76
	<b>Volume</b>	11.70	1420.00	139.09	168.45
<b>05-06</b>	<b>Price</b>	749.10	8010.14	2688.38	947.77
	<b>Volume</b>	3.20	1419.00	164.09	193.88
<b>06-07</b>	<b>Price</b>	577.98	2499.87	2779.19	946.95
	<b>Volume</b>	3.20	1419.00	173.18	213.43
<b>07-08</b>	<b>Price</b>	749.03	2500.13	2861.07	985.46
	<b>Volume</b>	3.20	1443.00	196.48	221.38
<b>08-09</b>	<b>Price</b>	999.05	9200.54	3109.19	1220.91
	<b>Volume</b>	3.20	1485.00	224.95	233.56
<b>09-10</b>	<b>Price</b>	999.08	9600.78	3294.83	1255.15
	<b>Volume</b>	3.60	1480.00	282.29	237.68
<b>10-11</b>	<b>Price</b>	1018.67	10300.43	3526.11	1401.37
	<b>Volume</b>	3.60	1635.07	422.26	286.17
<b>11-12</b>	<b>Price</b>	999.54	11302.46	3700.91	1505.67
	<b>Volume</b>	3.60	1709.15	466.18	294.35
<b>12-13</b>	<b>Price</b>	699.80	11750.93	3664.07	1522.26
	<b>Volume</b>	23.40	1646.53	423.76	279.74
<b>13-14</b>	<b>Price</b>	899.14	13000.04	3558.89	1527.38
	<b>Volume</b>	23.40	1635.70	415.43	272.71
<b>14-15</b>	<b>Price</b>	899.21	13200.03	3659.17	1702.28

Hours	Parameter	Minimum	Maximum	Mean	Standard Deviation
	Volume	23.40	1706.24	469.91	286.90
15-16	Price	502.03	13600.56	3627.16	1767.21
	Volume	23.40	1702.70	475.59	288.89
16-17	Price	506.44	13900.55	3458.78	1788.64
	Volume	3.60	1652.29	393.75	249.41
17-18	Price	699.35	13120.58	3404.54	1652.45
	Volume	3.60	1416.82	354.59	230.65
18-19	Price	1499.26	12150.55	3625.46	1554.46
	Volume	12.70	1584.01	340.48	233.08
19-20	Price	1499.38	13211.75	4403.21	1702.98
	Volume	11.30	1699.00	359.74	247.45
20-21	Price	1198.01	11250.16	4245.57	1476.44
	Volume	7.64	1565.00	295.74	228.39
21-22	Price	1198.41	13121.68	4016.75	1537.76
	Volume	4.90	1510.00	241.50	219.82
22-23	Price	1198.48	11249.95	3550.71	1480.34
	Volume	5.20	1177.27	223.21	198.24
23-24	Price	899.44	10621.63	3166.82	1477.59
	Volume	6.60	1177.72	205.89	189.70

It is evident from Table 3 that the average price reaches a maximum during the evening hours (19-20, 20-21, and 21-22 hours of the day), whereas the average volume cleared in the bid area reaches a peak in the afternoon hours of the day (11-12, 14-15, 15-16). The hours (15-16 and 16-17) also are the most volatile hours in terms of price. Table 4 provides summary statistics for the hourly day ahead prices and volume cleared in W2 bid area for the period from 1 April 2012 to 31 March 2014, respectively.

**Table 4: Summary Statistics of Electricity purchased in W2 Bid Area (April 1, 2012 to March 31, 2014)**

Hours	Parameter	Minimum	Maximum	Mean	Standard Deviation
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Hours	Parameter	Minimum	Maximum	Mean	Standard Deviation
00-01	Price	924.76	7985.19	2551.24	972.55
	Volume	163.85	1913.45	851.20	382.29
01-02	Price	809.65	7101.27	2437.98	927.08
	Volume	58.00	1794.70	767.94	371.47
02-03	Price	800.86	7051.35	2261.27	844.00
	Volume	23.85	1828.65	715.89	366.39
03-04	Price	800.88	6500.93	2147.06	824.15
	Volume	17.40	1729.95	694.59	363.35
04-05	Price	800.12	6108.84	2075.60	786.14
	Volume	17.40	1710.45	689.96	364.12
05-06	Price	887.18	6111.15	2166.60	736.21
	Volume	17.40	2117.70	726.91	381.65
06-07	Price	869.40	6006.39	2278.76	662.79
	Volume	53.85	2214.65	789.22	419.86
07-08	Price	884.12	5258.18	2437.28	721.90
	Volume	100.30	2273.05	876.86	471.66
08-09	Price	905.26	5750.61	2726.74	925.84
	Volume	146.68	2527.30	969.46	501.67
09-10	Price	992.98	6329.73	2889.14	1008.26
	Volume	169.55	2663.20	1069.64	470.41
10-11	Price	965.99	6926.42	3098.48	1050.64
	Volume	232.05	2923.30	1258.42	492.35
11-12	Price	999.27	8000.53	3227.20	1069.89
	Volume	255.80	2944.30	1339.97	489.05
12-13	Price	999.12	8000.54	3155.08	1017.38
	Volume	222.05	2868.35	1236.14	464.57
13-14	Price	999.14	8000.36	3062.66	1020.25
	Volume	192.05	2712.15	1156.70	429.81
14-15	Price	999.16	8000.41	3134.55	1029.95
	Volume	214.80	2817.35	1242.72	452.21
15-16	Price	999.19	8000.45	3099.80	1006.94
	Volume	215.80	2773.65	1261.67	461.83
16-17	Price	943.10	7881.27	2983.16	983.31
	Volume	170.80	2497.16	1175.91	436.13
17-18	Price	941.28	6651.69	2844.51	912.26

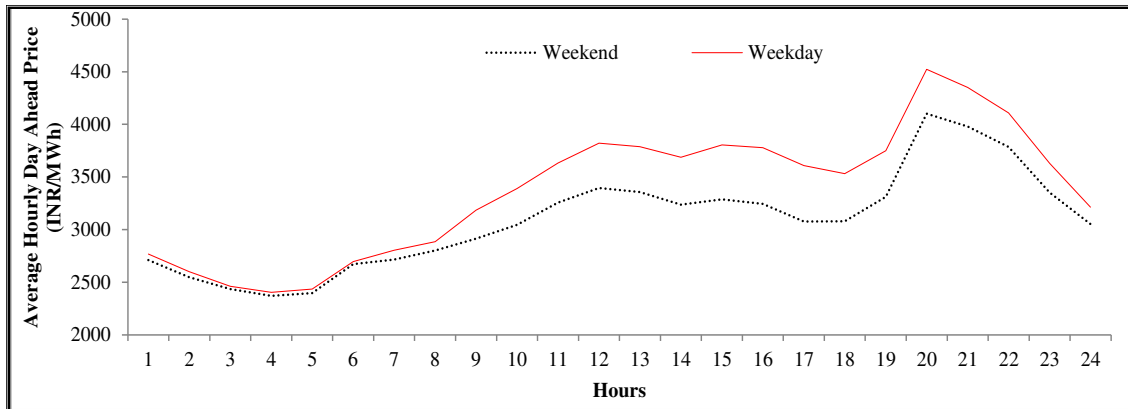


Hours	Parameter	Minimum	Maximum	Mean	Standard Deviation
	Volume	163.30	2082.33	1014.05	362.45
18-19	Price	924.54	6651.81	3042.57	956.04
	Volume	150.90	2063.55	1003.08	389.51
19-20	Price	954.52	7805.34	3378.29	1024.42
	Volume	215.80	2234.83	1040.02	399.54
20-21	Price	899.89	7858.24	3183.52	985.65
	Volume	264.45	2007.50	950.76	347.24
21-22	Price	956.44	7858.23	3114.14	976.36
	Volume	226.95	2189.25	1006.19	406.59
22-23	Price	1188.01	8000.62	3031.59	1057.62
	Volume	325.45	1959.55	992.89	390.71
23-24	Price	1062.13	8000.42	2751.35	1154.65
	Volume	275.20	1998.30	929.52	374.15

In the period from April 2012 to March 2014, the hourly average prices are seen to be on the higher side during the afternoon (11-12, 12-13 hours) and evening hours (19-20,20-21,21-22 hours), whereas average volume is maximum in the 11-12th hour of the day. The average prices witness a low in the early morning hours (03-04, 04-05) of the day.

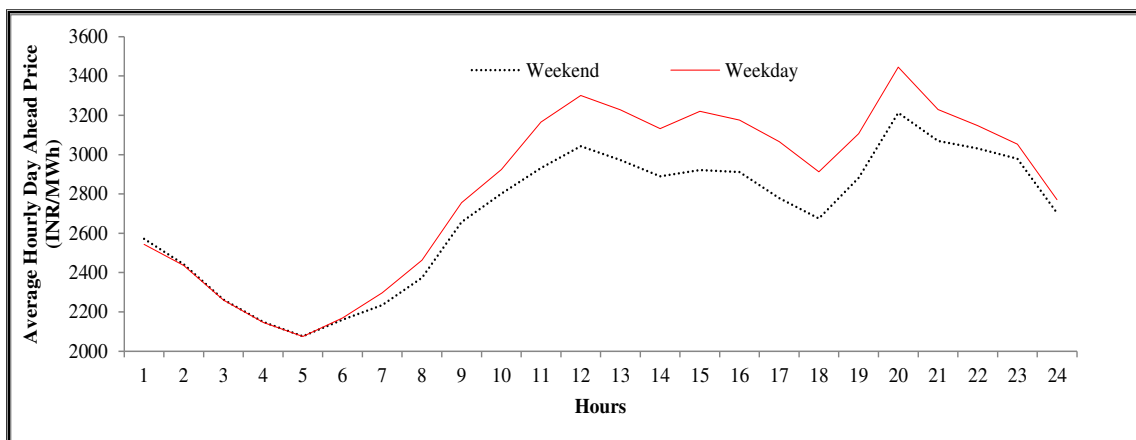
It has been acknowledged in previous studies (Cuaresma et al., 2004) that there is a presence of a weekday effect in electricity prices and volume of electricity cleared at power exchanges. We check for weekday effect in electricity prices for W2 bid area and find that during the weekdays (Monday to Friday), there is a higher volume of electricity cleared on the power exchange compared to weekends (Saturday and Sunday). This could be attributed to the heavy usage of electricity by factories and industries during the weekdays and closing down of factories over the weekends.

Figure 4 and Figure 5 present the day ahead average price for each hour for weekdays (Monday to Friday) (shown by red solid line) and day ahead average price for each hour for weekend (Saturday and Sunday) (shown by dotted black line) for the two sample periods (1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014), respectively.



Source: Authors Work; Compiled from IEX

**Figure 4: Average Hourly Day Ahead Prices (April 1, 2010 to March 31, 2012) for W2 Bid Area**



Source: Authors Work; Compiled from IEX

**Figure 5: Average Hourly Day Ahead Prices (April 1, 2012 to March 31, 2014) for W2 Bid Area**

From the pattern in both the figures (Figure 4 and Figure 5), we can observe that the average day ahead hourly prices on weekdays are higher than the average day ahead hourly prices on weekends. Thus, a preliminary examination of average hourly day ahead prices indicates a presence of weekday effect.

Section 3.1 explores the methodology employed to study effect of the weekday effect on the mean and volatility of day ahead hourly electricity contracts. Section 3.2 discusses the methodology for analysing the effect of the introduction of fifteen minute contracts in the day ahead electricity market.

### 3.1 Impact of Weekday Effect and Volume

Returns have been calculated using logarithm of hourly day ahead prices of W2 Bid area for each of the twenty four hours for the two sets of periods (First period 1 April 2010 to 31 March 2012 and Second period 1 April 2012 to 31 March 2014). Table 5 and Table 6 report the summary statistics of the electricity return series for the twenty four hours for the two sets of periods, respectively.

**Table 5: Summary Statistics of Electricity Return Series on W2 Bid Area (2010-12)**

Hours	Minimum	Maximum	Mean	Standard Deviation	ADF Test Statistic <sup>^</sup>
00-01	-0.330	0.368	0.000	0.064	-14.660**
01-02	-0.333	0.368	0.000	0.062	-14.112**
02-03	-0.309	0.316	0.000	0.060	-15.611**
03-04	-0.256	0.654	0.001	0.063	-14.786**
04-05	-0.249	0.549	0.000	0.062	-15.086**
05-06	-0.337	0.361	0.000	0.062	-15.075**
06-07	-0.285	0.417	0.000	0.056	-13.921**
07-08	-0.284	0.368	0.000	0.057	-14.727**
08-09	-0.361	0.243	0.000	0.058	-15.511**
09-10	-0.413	0.303	0.000	0.064	-15.986**
10-11	-0.441	0.345	0.000	0.070	-16.392**
11-12	-0.441	0.413	0.000	0.073	-16.741**
12-13	-0.413	0.403	0.000	0.078	-16.519**
13-14	-0.364	0.398	0.000	0.075	-16.158**
14-15	-0.415	0.439	0.000	0.082	-16.355**
15-16	-0.725	0.739	0.000	0.088	-16.270**
16-17	-0.609	0.644	0.000	0.087	-15.290**
17-18	-1.046	1.051	0.000	0.092	-15.107**
18-19	-0.507	0.399	0.000	0.076	-16.445**
19-20	-0.398	0.447	0.000	0.079	-15.573**
20-21	-0.336	0.284	0.000	0.070	-15.884**

<b>21-22</b>	-0.339	0.237	0.000	0.063	-15.409**
<b>22-23</b>	-0.329	0.230	0.000	0.060	-14.989**
<b>23-24</b>	-0.258	0.347	0.000	0.062	-14.412**

^ The critical value at 5% level for ADF(4 with intercept) is -2.86; \*\* Denotes rejection at 5% level

From Table 5 it is found that return series exhibit volatility (standard deviation) and are stationary for all the day ahead hours during the period from 1 April 2010 to 31 March 2012.

**Table 6: Summary Statistics of Electricity Return Series on W2 Bid Area (2012-14)**

<b>Hours</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Standard Deviation</b>	<b>ADF Test Statistic<sup>^</sup></b>
<b>00-01</b>	-0.734	0.623	0.000	0.127	-12.435**
<b>01-02</b>	-0.620	0.511	0.000	0.126	-12.540**
<b>02-03</b>	-0.609	0.558	0.000	0.120	-12.678**
<b>03-04</b>	-0.533	0.526	0.000	0.121	-12.025**
<b>04-05</b>	-0.596	0.540	0.000	0.126	-12.549**
<b>05-06</b>	-0.443	0.507	0.000	0.115	-12.267**
<b>06-07</b>	-0.627	0.431	0.000	0.116	-13.513**
<b>07-08</b>	-0.511	0.468	0.000	0.116	-13.222**
<b>08-09</b>	-0.530	0.606	0.000	0.123	-13.252**
<b>09-10</b>	-0.899	0.492	0.000	0.136	-12.902**
<b>10-11</b>	-0.695	0.736	0.000	0.149	-14.656**
<b>11-12</b>	-1.388	0.790	0.000	0.164	-15.658**
<b>12-13</b>	-1.388	0.783	0.000	0.165	-15.221**
<b>13-14</b>	-1.468	0.840	0.000	0.166	-14.749**
<b>14-15</b>	-1.393	0.774	0.000	0.166	-15.469**
<b>15-16</b>	-1.038	0.693	0.000	0.160	-14.904**
<b>16-17</b>	-0.916	0.735	0.000	0.161	-15.274**
<b>17-18</b>	-0.829	0.810	0.000	0.159	-14.796**
<b>18-19</b>	-0.826	0.731	0.000	0.167	-14.550**
<b>19-20</b>	-0.848	0.841	0.000	0.167	-15.320**
<b>20-21</b>	-0.803	0.870	0.000	0.150	-15.165**
<b>21-22</b>	-0.750	0.830	0.000	0.131	-14.456**
<b>22-23</b>	-0.777	0.638	0.000	0.130	-13.530**
<b>23-24</b>	-0.738	0.528	0.000	0.141	-14.406**

^ The critical value at 5% level for ADF(4 with intercept) is -2.86 \*\* Denotes rejection at 5% level

From Table 6 it is found that the return series (2012-14) exhibit higher volatility compared to earlier period (2010-12) and are stationary for all the day ahead hours during the period from 1 April 2012 to 31 March 2014.

### 3.1.1 Weekday effect

As is true in case of financial time series as well as storable commodity futures return series, electricity day ahead return series also do not exhibit constant variance over time, thus, so as to study electricity return series, we can use a combination of basic autoregressive model and a GARCH<sup>2</sup> model, which allows the variance to change over the course of time.

#### Model IA

A combination of ARMA-GARCH model is applied to estimate the presence weekday effect on the return of hour. In this model (Model IA), we include an AR term, MA term, and a dummy variable in the mean equation (Equation 1) of the specification for each of the twenty four hours. The dummy variable takes the value of 0 on weekends (Saturday or Sunday) and dummy variable takes the value of 1 on weekdays (Monday, Tuesday, Wednesday, Thursday, or Friday). The model is run separately for each of the twenty four hours for the two sets of periods of study, i.e., 1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014. Equation 1 and Equation 2 describe the Model IA.

<b>Model IA</b>	
<b>Mean Equation:</b> $r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \beta_2 D_t + \varepsilon_t$ ;	$\varepsilon_t \sim N(0, h_t^2)$ (Equation 1)
<b>Variance Equation:</b> $h_t^2 = \beta_3 + \beta_4 \varepsilon_{t-1}^2 + \beta_5 h_{t-1}^2$	(Equation 2)

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $D_t$  accounts for the dummy variable (0-weekend, 1- weekdays);  $\beta_2$  is the coefficient of the dummy variable  $D_t$ ;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_3$  is the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_4$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_5$  is the coefficient of GARCH term.

<sup>2</sup> To check whether or not GARCH models can employed for the return series, ARCH-LM tests were performed using the series.

## Model IB

A combination of ARMA-GARCH model is applied to estimate the presence weekday effect on the return of hour as well as the volatility of electricity return. In this model (Model IB), we include an AR term, MA term, and a dummy variable in the mean equation (Equation 1) of the specification for each of the twenty four hours. We also include the weekday dummy variable in the variance equation (Equation 3). The dummy variable takes the value of 0 on weekends (Saturday or Sunday) and dummy variable takes the value of 1 on weekdays (Monday, Tuesday, Wednesday, Thursday, or Friday). The model is run separately for each of the twenty four hours for the two sets of periods of study, i.e., 1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014. Equation 1 and Equation AR 3 describe the Model IB.

### Model IB

$$\text{Mean Equation: } r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \beta_2 D_t + \varepsilon_t; \quad \varepsilon_t \sim N(0, h_t^2) \text{ (Equation 1)}$$

$$\text{Variance Equation: } h_t^2 = \beta_3 + \beta_4 \varepsilon_{t-1}^2 + \beta_5 h_{t-1}^2 + \beta_6 D_t \text{ (Equation 3)}$$

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $D_t$  accounts for the dummy variable (0-weekend, 1- weekdays);  $\beta_2$  is the coefficient of the dummy variable  $D_t$ ;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_3$  is the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_4$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_5$  is the coefficient of GARCH term.  $\beta_6$  is the coefficient of the dummy variable  $D_t$  in the variance equation.

### 3.1.2 Weekday effect and Traded Volume

In this section, we discuss the Model IIA and Model IIB, here we include the impact of traded volume on the return volatility.

### Model IIA

The first specification (Model IIA) is a ARMA-GARCH model which the mean equation (Equation 1) includes an AR term, MA term and a dummy variable (1-weekdays and 0-weekend) term. Further, the variance equation (Equation 4) includes a log of lagged traded volume term to take into account the impact of volume traded of electricity traded in the previous period on the

volatility of electricity periods of study, i.e., 1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014, respectively. Equation 1 and Equation 4 describe the model specification (Model IIA).

<b>Model IIA</b>	
<b>Mean Equation:</b> $r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \beta_2 D_t + \varepsilon_t$ ;	$\varepsilon_t \sim N(0, h_t^2)$ (Equation 1)
<b>Variance Equation:</b> $h_t^2 = \beta_3 + \beta_4 \varepsilon_{t-1}^2 + \beta_5 h_{t-1}^2 + \beta_7 \log V_{t-1}$	(Equation 4)

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $D_t$  accounts for the dummy variable (0-weekend, 1- weekdays);  $\beta_2$  is the coefficient of the dummy variable  $D_t$ ;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_3$  is the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_4$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_5$  is the coefficient of GARCH term.  $\log V_{t-1}$  represents the logarithmic value of volume traded in the previous period;  $\beta_7$  represents for the coefficient of the log of volume traded in the previous period in the variance equation.

### Model IIB

This specification is also a ARMA GARCH model which includes an AR term, MA term with a dummy variable for weekday effect in the mean equation (Equation 1). In this specification (Model IIB), we include two terms in the variance equation (Equation 5) other than ARCH and GARCH terms, log traded volume term as well as a dummy variable to analyse the impact of volume traded and the weekday effect on the volatility of the electricity returns, respectively. The model is run separately for each of the twenty four hours for the two sets of periods of study, i.e., 1 April 2010 to 31 March 2012 and 1 April 2012 to 31 March 2014. Equation 1 and Equation 5 describe the second specification of Model IIB.

<b>Model IIB</b>	
<b>Mean Equation:</b> $r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \beta_2 D_t + \varepsilon_t$ ;	$\varepsilon_t \sim N(0, h_t^2)$ (Equation 1)
<b>Variance Equation:</b> $h_t^2 = \beta_3 + \beta_4 \varepsilon_{t-1}^2 + \beta_5 h_{t-1}^2 + \beta_6 D_t + \beta_7 \log V_{t-1}$	(Equation 5)

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $D_t$  accounts for the dummy variable (0-weekend, 1- weekdays);  $\beta_2$  is the coefficient of the dummy variable  $D_t$ ;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_3$  is the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_4$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_5$  is the coefficient of GARCH term,  $\log V_{t-1}$  represents the logarithmic value of volume traded in the previous period;  $\beta_6$  is the coefficient of the dummy variable  $D_t$  in the variance equation.  $\beta_7$  represents for the coefficient of the log of volume traded in the previous period in the variance equation.

### 3.1.2 The impact of introduction of fifteen minute day ahead electricity contracts

The fifteen minute day ahead electricity contracts were introduced on 1 April 2012 at IEX. In this section, we use the consolidated data for returns of hourly day ahead prices for the entire period of study, i.e., from 1 April 2010 to 31 March 2014.

#### Model IIIA

An ARMA-GARCH model is used to assess the impact of the introduction of the fifteen minute contract on the return, by using a dummy variable term ( $D'_t$ ) in the mean equation (Equation 6). The dummy variable ( $D'_t$ ) takes the value 0 for the period 1 April 2010 to 31 March 2012 which is the period which had an absence of fifteen minute contracts being traded on the Indian Energy Exchange. The dummy variable ( $D'_t$ ) takes the value 1 for the period from 1 April 2012 to 31 March 2014. The model is run separately for each of the twenty four hours for the consolidated period (1 April 2010 to 31 March 2014). Equation 6 and Equation 7 describe the model (Model IIIA).

<b>Model IIIA</b>	
<b>Mean Equation:</b> $r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \beta_9 D'_t + \varepsilon_t$	$\varepsilon_t \sim N(0, h_t^2)$ (Equation 6)
<b>Variance Equation:</b> $h_t^2 = \beta_{10} + \beta_{11} \varepsilon_{t-1}^2 + \beta_{12} h_{t-1}^2$	(Equation 7)

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $D'_t$  accounts for the dummy variable (0-period before 1 April 2012 and 1- for period from 1 April 2012);  $\beta_9$  is the coefficient of the dummy variable  $D'_t$ ;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_{10}$  is



the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_{11}$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_{12}$  is the coefficient of GARCH term in the variance equation.

### Model IIIB

Through Model-IIIB, we try to estimate the impact of the introduction of the shorter contracts (fifteen minute contracts) on the volatility exhibited by the electricity returns. This is performed by using a dummy variable term ( $D'_t$ ) in the variance equation (Equation 9). The dummy variable ( $D'_t$ ) takes the value 0 for the period 1 April 2010 to 31 March 2012 which is the period which did not have a provision of fifteen minute contracts traded on the Indian Energy Exchange. The dummy variable takes the value of 1 for the period after 1 April 2012 (introduction of fifteen minute contracts), i.e., from 1 April 2012 to 31 March 2014. The model is run separately for each of the twenty four hours for the consolidated period (1 April 2010 to 31 March 2014). Equation 8 and Equation 9 describe the model (Model IIIB).

<b>Model IIIB</b>	
<b>Mean Equation:</b> $r_t = \mu_1 + \sum_{i=1}^p \delta_i r_{t-i} + \sum_{j=1}^q \delta_j \varepsilon_{t-j} + \varepsilon_t$	$\varepsilon_t \sim N(0, h_t^2)$ (Equation 8)
<b>Variance Equation:</b> $h_t^2 = \beta_{13} + \beta_{14} \varepsilon_{t-1}^2 + \beta_{15} h_{t-1}^2 + \beta_{16} D'_t$	(Equation 9)

Where  $r_t$  represents the return for bid area at time  $t$ ;  $\mu_1$  represents the constant term;  $\delta_i$  the  $i$ th autoregressive coefficient;  $\delta_j$  the  $j$ th moving average coefficient;  $\varepsilon_t$  represents the error term;  $h_t^2$  is the conditional variance term;  $\beta_{13}$  is the constant term in the variance equation;  $\varepsilon_{t-1}^2$  is news about the volatility from previous period (ARCH term);  $\beta_{14}$  is the coefficient of ARCH term;  $h_{t-1}^2$  accounts for the previous period's forecast variance (GARCH term);  $\beta_{15}$  is the coefficient of GARCH term in the variance equation.  $D'_t$  accounts for the dummy variable (0-period before 1 April 2012 and 1- for period after 1 April 2012);  $\beta_{16}$  is the coefficient of the dummy variable  $D'_t$  in the variance equation.

## 4 Empirical Results

This section is broadly divided into two sections. In Section 4.1, we discuss the results of the specifications to assess the impact of current return, impact of weekday effect on current return and volatility (Model IA and Model IB) and the effect of traded volume on return volatility

(Model IIA and Model IIB) for two sets of periods separately (2010 to 2012 and 2012 to 2014). While in Section 4.2, we analyse the impact of introduction of fifteen minute contracts on the mean and volatility of return (Model IIIA and Model IIIB) over the consolidated period from 2010 to 2014.

## 4.1 Impact of Weekday Effect and Volume

### 4.1.1 The effect of weekday effect

#### Model IA

In Model IA, we assess the impact of weekday effect ( $\beta_2$ ) on return using a dummy variable (1-weekdays; 0-weekend) with a ARMA GARCH model for each hour separately for the two sets of periods. For each hour, we calculate AIC values using different orders of ARMA in ARMA GARCH model. The AIC values for ARMA parameters in Equation 1 (Model IA) are reported for hours in Table 7 to Table 30 for 2010-12. Table 31 reports the results of the estimation for the period 2010-12.

**Table 7: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 00-01 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.7438	-2.7422	-2.7398	-2.7495	-2.7606	-2.7721
AR(1)	-2.7424	-2.7726	-2.7420	-2.7794	-2.7772	-2.7750
AR(2)	-2.7396	-2.7758	-2.7790	-2.7761	-2.7710	-2.7756
AR(3)	-2.7465	-2.7806	-2.7512	-2.7797	-2.7831	-2.7819
AR(4)	-2.7535	-2.7779	-2.7757	-2.7782	-2.7783	-2.7936
AR(5)	-2.7615	-2.7751	-2.7736	-2.7833	-2.7961	<b>-2.7995</b>

**Table 8: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 01-02 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.861783	-2.862772	-2.854982	-2.854006	-2.883543	-2.882351
AR(1)	-2.862442	-2.878508	-2.874005	-2.896573	-2.902961	-2.90018
AR(2)	-2.861842	-2.876906	-2.867081	-2.907919	-2.914462	-2.913128
AR(3)	-2.85588	-2.903374	-2.907333	-2.904432	-2.914203	-2.911969
AR(4)	-2.882794	-2.902015	-2.916739	-2.91575	<b>-2.917293</b>	-2.874094
AR(5)	-2.884126	-2.893787	-2.9145	-2.911115	-2.91295	-2.891401

**Table 9: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 02-03 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.939067	-2.93689	-2.934098	-2.934076	-2.952581	-2.95518
AR(1)	-2.936813	-2.94413	-2.941357	-2.963796	-2.96634	-2.96371
AR(2)	-2.934128	-2.941351	-2.983353	-2.970102	-2.971492	-2.969677
AR(3)	-2.932736	-2.968505	-2.968854	-2.96124	-2.973917	-2.972801
AR(4)	-2.941489	-2.967947	-2.972918	-2.972746	-2.964897	<b>-3.008346</b>
AR(5)	-2.945504	-2.965132	-2.967476	-2.969996	-2.967606	-3.000719

Table 10: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 03-04 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-3.01847	-3.015654	-3.018479	-3.017985	-3.022053	-3.023766
AR(1)	-3.015657	-3.012767	-3.015995	-3.036894	-3.035126	-3.021003
AR(2)	-3.017385	-3.034837	-3.036874	-3.014562	-3.028251	-3.019127
AR(3)	-3.016508	<b>-3.037014</b>	-3.024859	-3.021921	-3.024687	-3.02298
AR(4)	-3.020083	-3.035174	-3.017185	-3.02585	-3.02296	-3.023568
AR(5)	-3.020546	-3.017805	-3.02582	-3.023182	-3.023657	-3.020341

Table 11: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 04-05 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.940896	-2.938452	-2.935996	-2.950312	-2.953346	-2.956119
AR(1)	-2.93836	-2.935632	-2.933535	-2.96123	-2.961868	-2.954572
AR(2)	-2.935629	-2.960612	-2.95696	-2.964494	-2.958454	-2.962579
AR(3)	-2.947146	-2.962625	-2.964297	-2.961701	-2.958016	-2.956496
AR(4)	-2.948914	-2.962122	-2.957645	-2.95592	<b>-2.968264</b>	-2.954112
AR(5)	-2.951929	-2.960093	-2.950967	-2.961078	-2.958282	-2.953831

Table 12: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 05-06 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.917984	-2.918027	-2.915123	-2.923972	-2.967255	-2.973371
AR(1)	-2.9183	-2.916894	-2.915839	-2.966953	-2.974086	-2.971737
AR(2)	-2.915397	-2.91565	-2.960873	-2.975936	-2.973055	-2.974718
AR(3)	-2.915803	-2.968113	-2.973163	-2.981547	-2.973599	-2.974165
AR(4)	-2.948167	-2.972971	-2.972432	-2.970589	<b>-2.981561</b>	-2.978702
AR(5)	-2.954904	-2.975339	-2.970818	-2.972694	-2.978711	-2.979523

Table 13: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 06-07 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-3.124905	-3.123483	-3.124767	-3.127467	-3.1474	-3.149592
AR(1)	-3.123681	-3.121022	-3.122778	-3.152213	-3.161357	-3.158823
AR(2)	-3.122679	-3.120978	-3.130264	-3.161034	-3.16221	-3.159282
AR(3)	-3.127333	-3.162273	-3.159348	-3.155634	-3.159332	-3.157903
AR(4)	-3.140043	-3.159357	-3.161395	-3.160459	-3.157527	-3.155201
AR(5)	-3.137655	-3.135764	-3.159521	<b>-3.168485</b>	-3.15634	-3.167236

Table 14: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 07-08 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.973492	-2.974182	-2.974217	-2.979371	-2.999193	-3.002082
AR(1)	-2.973802	-2.976705	-2.973965	-3.010988	-3.010916	-3.000143
AR(2)	-2.974225	-2.973956	-3.012055	-3.009239	-3.01243	-3.009574
AR(3)	-2.976215	-3.011898	-3.008598	-3.003241	-2.993334	-3.013308
AR(4)	-2.988788	-3.009719	-3.012901	-3.019149	-3.017932	<b>-3.037583</b>
AR(5)	-2.99123	-3.008352	-3.010407	-3.017927	-3.013752	-3.020542

Table 15: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 08-09 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.979834	-2.9775	-2.975428	-2.977846	-2.994721	-3.004435
AR(1)	-2.977468	-2.975593	-3.004203	-2.993616	-3.007921	-3.005895
AR(2)	-2.975353	-3.005378	-3.004008	-2.999096	-3.005611	-2.997173
AR(3)	-2.975834	-3.006079	-3.002645	-2.969931	-3.002519	-2.998785
AR(4)	-2.98859	-3.005722	-3.004554	-3.00169	-2.992864	-3.00019
AR(5)	-2.996922	-3.00364	-3.001782	-3.016135	-3.000189	<b>-3.023152</b>

Table 16: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 09-10 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.83281	-2.832398	-2.829651	-2.829321	-2.839973	-2.84386
AR(1)	-2.832375	-2.85415	-2.827899	-2.849701	-2.847903	-2.853308
AR(2)	-2.829577	-2.828061	-2.849991	-2.847482	-2.849203	-2.840298
AR(3)	-2.827374	-2.849478	-2.844164	-2.857656	-2.848624	-2.857904
AR(4)	-2.833972	-2.847094	-2.848853	-2.827862	-2.845022	-2.842192
AR(5)	-2.838054	-2.848283	-2.853755	-2.857402	-2.845105	<b>-2.859324</b>

Table 17: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 10-11 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.673885	-2.691867	-2.691755	-2.704653	-2.710438	-2.71222
AR(1)	-2.689935	-2.734097	-2.735878	-2.734847	-2.733044	-2.730874
AR(2)	-2.687729	-2.736564	-2.735521	-2.733134	-2.733931	-2.733387
AR(3)	-2.691504	-2.735213	-2.740739	-2.736431	-2.706351	-2.751701
AR(4)	-2.698002	-2.732653	-2.736541	<b>-2.799667</b>	-2.727949	-2.764243
AR(5)	-2.698706	-2.731073	-2.739291	-2.764602	-2.764116	-2.726428

Table 18: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 11-12 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.609686	-2.622713	-2.621915	-2.662999	-2.667305	-2.69189
AR(1)	-2.621789	-2.67393	-2.617557	-2.681071	-2.678451	-2.690904
AR(2)	-2.621033	-2.671506	-2.668177	-2.680647	-2.676451	-2.698173
AR(3)	-2.631926	-2.683025	-2.680243	-2.725814	-2.675116	-2.695393
AR(4)	-2.640831	-2.68024	-2.679749	-2.727784	-2.724998	-2.692708
AR(5)	-2.652294	-2.677454	-2.6757	-2.71251	-2.709728	<b>-2.774534</b>

Table 19: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 12-13 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.545659	-2.563477	-2.565121	-2.589764	-2.595011	-2.622814
AR(1)	-2.565447	-2.572399	-2.573761	-2.621959	-2.620425	-2.622089
AR(2)	-2.569949	-2.571865	-2.613348	-2.622456	-2.591843	-2.621463
AR(3)	-2.577784	-2.624644	-2.579027	-2.690512	-2.688185	-2.638658
AR(4)	-2.587768	-2.62209	-2.621683	-2.688272	-2.611651	-2.657246
AR(5)	-2.588373	-2.619333	-2.627593	-2.658631	-2.655962	<b>-2.702934</b>

**Table 20: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 13-14 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.596777	-2.604498	-2.61493	-2.627946	-2.627777	-2.651732
AR(1)	-2.608127	-2.642026	-2.621206	-2.659074	-2.658281	-2.6589
AR(2)	-2.61883	-2.618634	-2.650185	-2.659393	-2.661968	-2.65703
AR(3)	-2.622545	-2.660711	-2.658272	-2.715879	-2.716504	-2.665195
AR(4)	-2.629692	-2.658621	-2.667543	-2.717491	-2.729115	-2.647746
AR(5)	-2.627709	-2.656954	-2.669318	-2.715414	-2.727904	<b>-2.768497</b>

**Table 21: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 14-15 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.46506	-2.493023	-2.492134	-2.528753	-2.540855	-2.555125
AR(1)	-2.492	-2.489203	-2.487623	-2.570246	-2.568817	-2.564969
AR(2)	-2.489198	-2.486503	-2.541462	-2.567848	-2.572439	-2.58299
AR(3)	-2.497232	-2.565488	-2.563007	-2.633375	-2.561758	-2.587592
AR(4)	-2.520074	-2.563331	-2.560035	-2.631094	-2.59747	-2.568403
AR(5)	-2.526842	-2.571723	-2.570845	-2.55313	-2.615958	<b>-2.685063</b>

**Table 22: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 15-16 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.343382	-2.372769	-2.364845	-2.402182	-2.436823	-2.455798
AR(1)	-2.372648	-2.370161	-2.367809	-2.500171	-2.503336	-2.515859
AR(2)	-2.369939	-2.367456	-2.4928	-2.512523	-2.530578	-2.521315
AR(3)	-2.374482	-2.491816	-2.48956	-2.632969	-2.448394	-2.480353
AR(4)	-2.418159	-2.430317	-2.459935	-2.630273	-2.57488	-2.535054
AR(5)	-2.424536	-2.474348	-2.455089	-2.466117	-2.510211	<b>-2.682187</b>

**Table 23: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 16-17 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.341666	-2.365125	-2.383307	-2.427354	-2.440121	-2.466135
AR(1)	-2.369158	-2.372603	-2.39318	-2.46668	-2.46395	-2.467462
AR(2)	-2.387158	-2.386982	-2.475961	-2.46511	-2.470635	-2.459539
AR(3)	-2.401014	-2.459095	-2.494425	-2.565164	-2.528525	-2.475051
AR(4)	-2.445881	-2.455207	-2.480799	-2.535751	-2.537594	-2.475781
AR(5)	-2.4462	-2.475321	-2.492339	-2.535223	-2.544951	<b>-2.626343</b>

**Table 24: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 17-18 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.25597	-2.298502	-2.306942	-2.304178	-2.420482	-2.479547
AR(1)	-2.303256	-2.301048	-2.304891	-2.50043	-2.497745	-2.49782
AR(2)	-2.298874	-2.296682	-2.529238	-2.401864	-2.5493	-2.521283
AR(3)	-2.297659	-2.429011	-2.483176	-2.519153	-2.559672	-2.585957
AR(4)	-2.327884	-2.49256	-2.553821	-2.44093	-2.543406	-2.534019
AR(5)	-2.325608	-2.501072	-2.555611	-2.465337	-2.544293	<b>-2.616033</b>

**Table 25: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 18-19 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.617232	-2.653661	-2.650987	-2.679774	-2.695713	-2.722874
AR(1)	-2.656075	-2.65458	-2.650298	-2.731266	-2.729148	-2.722284
AR(2)	-2.653958	-2.651859	-2.725211	-2.728815	-2.730815	-2.719961
AR(3)	-2.657669	-2.729552	-2.726622	-2.780719	-2.779315	-2.732123
AR(4)	-2.673619	-2.726853	-2.727528	-2.779606	-2.776817	-2.738278
AR(5)	-2.681165	-2.732389	-2.730249	-2.73841	-2.736982	<b>-2.792774</b>

**Table 26: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 19-20 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.536155	-2.56014	-2.557798	-2.575708	-2.587389	-2.609743
AR(1)	-2.55937	-2.611211	-2.617198	-2.618793	-2.616282	-2.612116
AR(2)	-2.55666	-2.618838	-2.618269	-2.616157	-2.618121	-2.617724
AR(3)	-2.557851	-2.61886	-2.616075	<b>-2.729608</b>	-2.726833	-2.621718
AR(4)	-2.566518	-2.616076	-2.621332	-2.726879	-2.623032	-2.616981
AR(5)	-2.569968	-2.616831	-2.622509	-2.625915	-2.632802	-2.632347

**Table 27: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 20-21 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.65311	-2.663987	-2.666171	-2.67867	-2.694338	-2.704329
AR(1)	-2.662272	-2.71121	-2.711843	-2.709079	-2.707911	-2.707345
AR(2)	-2.662879	-2.711776	-2.687354	-2.717302	-2.71755	-2.705468
AR(3)	-2.6641	-2.7105	-2.710137	-2.715123	-2.717803	-2.710865
AR(4)	-2.670142	-2.706361	-2.718423	-2.717994	<b>-2.767905</b>	-2.712299
AR(5)	-2.679518	-2.708868	-2.71629	-2.708117	-2.685406	-2.714623

**Table 28: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 21-22 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.82743	-2.830416	-2.831152	-2.843554	-2.857838	-2.864293
AR(1)	-2.82989	-2.873872	-2.871737	-2.874278	-2.872498	-2.871465
AR(2)	-2.828147	-2.871918	-2.867507	-2.875498	-2.877222	-2.870619
AR(3)	-2.830773	-2.87589	-2.875412	-2.87737	-2.877122	-2.872187
AR(4)	-2.838921	-2.87408	-2.878456	-2.900463	<b>-2.903066</b>	-2.875852
AR(5)	-2.842808	-2.871782	-2.870603	-2.877094	-2.872966	-2.875894

**Table 29: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 22-23 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.922845	-2.921049	-2.920258	-2.936984	-2.940508	-2.942793
AR(1)	-2.920922	-2.950415	-2.950006	-2.952392	-2.949837	-2.947911
AR(2)	-2.918849	-2.950584	-2.952467	-2.950351	-2.962121	-2.947934
AR(3)	-2.927267	-2.95313	-2.950613	-2.94868	-2.947719	-2.94529
AR(4)	-2.926841	-2.94817	-2.964748	-2.948126	-2.948924	-2.953574
AR(5)	-2.92769	-2.949022	-2.95952	<b>-2.972559</b>	-2.970605	-2.958677

Table 30: AIC values for ARMA parameters in Equation 1 (Model IA) for Hour 23-24 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.922845	-2.921049	-2.920258	-2.936984	-2.940508	-2.942793
AR(1)	-2.920922	-2.950415	-2.950006	-2.952392	-2.949837	-2.947911
AR(2)	-2.918849	-2.950584	-2.952467	-2.950351	-2.962121	-2.947934
AR(3)	-2.927267	-2.95313	-2.950613	-2.94868	-2.947719	-2.94529
AR(4)	-2.926841	-2.94817	-2.964748	-2.948126	-2.948924	-2.953574
AR(5)	-2.92769	-2.949022	-2.95952	<b>-2.972559</b>	-2.970605	-2.958677

Table 31: Results of Model IA -Equation 1 and Equation 2 (2010-12)

Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
00-01	<b>-0.0117</b> (0.0013)	(5,5)		<b>0.0165</b> (0.0012)	<b>0.0015</b> (0.0000)	<b>0.3088</b> (0.0000)	<b>0.3008</b> (0.0012)
		<b>0.7340</b> (0.0000)	<b>-0.9001</b> (0.0000)				
01-02	<b>-0.0161</b> (0.0000)	(4,4)		<b>0.0224</b> (0.0000)	<b>0.0024</b> (0.0000)	<b>0.3814</b> (0.0000)	<b>-0.0544</b> (0.0484)
		<b>-0.3286</b> (0.0362)	0.2411 (0.2109)				
02-03	<b>-0.0169</b> (0.0000)	(4,5)		<b>0.0238</b> (0.0000)	<b>0.0025</b> (0.0000)	<b>0.3552</b> (0.0000)	<b>-0.1499</b> (0.0000)
		<b>0.7407</b> (0.0000)	0.0472 (0.2593)				
03-04	<b>-0.0148</b> (0.0000)	(3,1)		<b>0.0211</b> (0.0000)	<b>0.0021</b> (0.0000)	<b>0.3362</b> (0.0000)	-0.0444 (0.6049)
		0.0272 (0.4831)	<b>-0.9961</b> (0.0000)				
04-05	<b>-0.0166</b> (0.0000)	(4,4)		<b>0.0228</b> (0.0000)	<b>0.0024</b> (0.0000)	<b>0.2466</b> (0.0000)	-0.0566 (0.639)
		<b>0.6878</b> (0.0000)	<b>-0.8071</b> (0.0000)				
05-06	<b>-0.0156</b> (0.0000)	(4,4)		<b>0.0212</b> (0.0000)	<b>0.0005</b> (0.0000)	<b>0.233</b> (0.0000)	<b>0.6093</b> (0.0000)
		<b>0.4766</b> (0.0000)	<b>-0.709</b> (0.0000)				
06-07	<b>-0.0193</b> (0.0000)	(5,3)		<b>0.0268</b> (0.0000)	<b>0.0007</b> (0.0000)	<b>0.2866</b> (0.0000)	<b>0.4411</b> (0.0000)
		<b>-0.196</b> (0.0000)	<b>-0.8215</b> (0.0000)				
07-08	<b>-0.0193</b> (0.0000)	(4,5)		<b>0.0268</b> (0.0000)	<b>0.0004</b> (0.0238)	<b>0.0533</b> (0.0085)	<b>0.7877</b> (0.0000)
		<b>0.5953</b> (0.0000)	-0.1239 (0.0633)				
08-09	<b>-0.0245</b>	(5,5)		<b>0.0344</b>	<b>0.0015</b>	<b>0.4288</b>	0.1235

Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
	(0.0000)	0.3554 (0.001)	-0.4702 (0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.1291)
09-10	-0.0292 (0.0000)	(5,5)		0.0407 (0.0000)	0.0018 (0.0000)	0.3267 (0.0000)	0.1857 (0.0314)
		0.544 (0.0000)	-0.6886 (0.0000)				
10-11	-0.0311 (0.0000)	(4,3)		0.0433 (0.0000)	0.0016 (0.0000)	0.6242 (0.0000)	0.1172 (0.0007)
		-0.0523 (0.2428)	-0.8914 (0.0000)				
11-12	-0.0395 (0.0000)	(5,5)		0.0549 (0.0000)	0.0014 (0.0000)	0.3927 (0.0000)	0.3006 (0.0000)
		0.7822 (0.0000)	-0.926 (0.0000)				
12-13	-0.0432 (0.0000)	(5,5)		0.0608 (0.0000)	0.0009 (0.0000)	0.4803 (0.0000)	0.4052 (0.0000)
		0.8053 (0.0000)	-0.848 (0.0000)				
13-14	-0.0529 (0.0000)	(5,5)		0.0739 (0.0000)	0.0015 (0.0000)	0.6085 (0.0000)	0.1493 (0.0144)
		0.8541 (0.0000)	-0.8641 (0.0000)				
14-15	-0.0606 (0.0000)	(5,5)		0.0838 (0.0000)	0.0009 (0.0000)	0.3437 (0.0000)	0.4994 (0.0000)
		0.7805 (0.0000)	-0.846 (0.0000)				
15-16	-0.0489 (0.0000)	(5,5)		0.0685 (0.0000)	0.0005 (0.0000)	0.4028 (0.0000)	0.5361 (0.0000)
		0.8524 (0.0000)	-0.8806 (0.0000)				
16-17	-0.0599 (0.0000)	(5,5)		0.0837 (0.0000)	0.0008 (0.0000)	0.3782 (0.0000)	0.5001 (0.0000)
		0.8501 (0.0000)	-0.8191 (0.0000)				
17-18	-0.0452 (0.0000)	(5,5)		0.0632 (0.0000)	0.0006 (0.0000)	0.34 (0.0000)	0.566 (0.0000)
		0.7116 (0.0000)	-0.814 (0.0000)				
18-19	-0.0337 (0.0000)	(5,5)		0.0465 (0.0000)	0.0005 (0.0000)	0.4311 (0.0000)	0.4905 (0.0000)
		0.6591 (0.0000)	-0.8207 (0.0000)				
19-20	-0.0301 (0.0000)	(3,3)		0.0423 (0.0000)	0.0013 (0.0000)	0.5326 (0.0000)	0.2506 (0.0000)
		0.8914 (0.0000)	-0.9964 (0.0000)				



Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
20-21	<b>-0.0323</b> (0.0000)	(4,4)		<b>0.0448</b> (0.0000)	<b>0.0008</b> (0.0002)	<b>0.144</b> (0.0000)	<b>0.6434</b> (0.0000)
		<b>-0.7128</b> (0.0000)	<b>0.8377</b> (0.0000)				
21-22	<b>-0.0246</b> (0.0000)	(4,4)		<b>0.0342</b> (0.0000)	<b>0.0007</b> (0.0004)	<b>0.1392</b> (0.0001)	<b>0.6464</b> (0.0000)
		-0.6726 (0.0000)	0.6595 (0.0000)				
22-23	<b>-0.0239</b> (0.0000)	(4,3)		<b>0.033</b> (0.0000)	<b>0.0007</b> (0.0000)	<b>0.1913</b> (0.0000)	<b>0.5862</b> (0.0000)
		-0.0503 (0.2749)	<b>-0.8692</b> (0.0000)				
23-24	<b>-0.0239</b> (0.0000)	(4,3)		<b>0.033</b> (0.0000)	<b>0.0007</b> (0.0000)	<b>0.1913</b> (0.0000)	<b>0.5862</b> (0.0000)
		-0.0503 (0.2749)	<b>-0.8692</b> (0.0000)				

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

For the first set of period (1 April 2010 to 31 March 2012), with respect to the weekday effect, the coefficient of dummy variable ( $\beta_2$ ) in the mean equation (Equation 1) is found to be positive and significant for all the twenty four hours. The positive sign supports that the price returns tend to be higher on weekdays as the prices are found to be higher on weekdays compared to weekends. The coefficients of ARCH effect ( $\beta_4$ ) in variance equation (Equation 2) are found to be significant for all the twenty four hours. While the coefficient of GARCH effect ( $\beta_5$ ) in the respective variance equations of hours (Equation 2) is able to explain the volatility in returns for twenty two hours out of the twenty four hours. GARCH effect is found to be insignificant in case of three hours out of the twenty four hours (03-04, 04-05, and 08-09).

The AIC values for ARMA parameters in mean equation (Equation 1 of Model IA) are reported for hours in Table 5.1.32 to Table 5.1.55 for the period 2012-14. Table 5.1.56 reports the results of the estimation for the period 2012-14.

**Table 32: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 00-01 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.578854	-1.576451	-1.57895	-1.580371	-1.584832	-1.583026
AR(1)	-1.576318	-1.57938	-1.582069	-1.579754	-1.629103	-1.576739
AR(2)	-1.577806	-1.581963	-1.627375	-1.624653	-1.625504	-1.623814
AR(3)	-1.580089	-1.580299	-1.62497	-1.627495	-1.62449	-1.623062
AR(4)	-1.585923	-1.628524	-1.629894	-1.629527	<b>-1.634143</b>	-1.631382
AR(5)	-1.58318	-1.58126	-1.625464	-1.622855	-1.620369	-1.631332

**Table 33: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 01-02 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.622726	-1.620198	-1.618741	-1.617293	-1.62122	-1.619152
AR(1)	-1.620201	-1.617434	-1.6179	-1.616184	-1.653586	-1.652212
AR(2)	-1.618562	-1.617893	-1.651337	-1.64863	-1.652474	-1.64977
AR(3)	-1.617801	-1.617103	-1.648735	-1.649267	-1.640343	-1.661588
AR(4)	-1.622944	-1.654393	-1.654524	-1.658422	<b>-1.666685</b>	-1.66425
AR(5)	-1.620608	-1.655143	-1.652537	-1.651498	-1.664263	-1.614895

Table 34: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 02-03 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.647935	-1.647005	-1.650154	-1.647399	-1.65334	-1.652138
AR(1)	-1.646285	<b>-1.702073</b>	-1.699467	-1.697105	-1.696343	-1.694065
AR(2)	-1.649054	-1.699443	-1.701406	-1.694723	-1.693579	-1.692135
AR(3)	-1.646288	-1.697211	-1.695351	-1.692718	-1.692672	-1.700617
AR(4)	-1.648518	-1.696004	-1.693962	-1.701096	-1.68259	-1.692861
AR(5)	-1.646	-1.69454	-1.692169	-1.695584	-1.701717	-1.696584

Table 35: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 03-04 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.607132	-1.611106	-1.609659	-1.607933	-1.607056	-1.604366
AR(1)	-1.609677	-1.645676	-1.641936	-1.641065	-1.63838	-1.6354
AR(2)	-1.608361	-1.643946	-1.640511	-1.63838	-1.646099	-1.633134
AR(3)	-1.606941	-1.641209	-1.638048	-1.646932	-1.63971	-1.639173
AR(4)	-1.605116	-1.638462	-1.635487	-1.644202	-1.617789	-1.654764
AR(5)	-1.60299	-1.635696	-1.643992	-1.636234	<b>-1.655004</b>	-1.649288

Table 36: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 04-05 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.539964	-1.539754	-1.551123	-1.548405	-1.548463	-1.545698
AR(1)	-1.538473	-1.581065	-1.578428	-1.581281	-1.579311	-1.578352
AR(2)	-1.549973	-1.578418	-1.58426	-1.581799	-1.582717	-1.580518
AR(3)	-1.547242	-1.582091	-1.571516	-1.57278	-1.548291	-1.56547
AR(4)	-1.545183	-1.580248	-1.582978	-1.559154	-1.586015	<b>-1.596241</b>
AR(5)	-1.542642	-1.577508	-1.576597	-1.577649	-1.572742	-1.594627

Table 37: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 05-06 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.630806	-1.631215	-1.628855	-1.627667	-1.629452	-1.628604
AR(1)	-1.631036	-1.681796	-1.631284	-1.62858	-1.681278	-1.678519
AR(2)	-1.628995	-1.631314	-1.679977	-1.625823	-1.677563	-1.678229
AR(3)	-1.627887	-1.628551	-1.67791	-1.642873	-1.676623	-1.675518
AR(4)	-1.628835	-1.681247	-1.678816	-1.676589	-1.675539	-1.673128
AR(5)	-1.626339	-1.678643	<b>-1.699781</b>	-1.674497	-1.673	-1.688404

Table 38: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 06-07 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.693962	-1.69134	-1.690322	-1.68894	-1.686174	-1.687737
AR(1)	-1.691326	-1.710163	<b>-1.745625</b>	-1.710704	-1.706981	-1.705521
AR(2)	-1.690374	-1.71243	-1.737273	-1.706989	-1.704234	-1.702802
AR(3)	-1.688397	-1.710675	-1.742942	-1.709004	-1.710314	-1.720872
AR(4)	-1.685631	-1.708035	-1.710501	-1.706887	-1.708196	-1.723477
AR(5)	-1.686694	-1.705472	-1.702804	-1.720804	-1.718135	-1.720637

Table 39: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 07-08 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.770838	-1.768697	-1.768088	-1.772403	-1.77033	-1.767564
AR(1)	-1.768499	-1.766707	-1.766489	-1.769652	-1.767739	-1.791112
AR(2)	-1.767686	-1.766977	-1.770728	-1.782569	-1.779804	-1.779008
AR(3)	-1.771903	-1.769234	-1.768084	-1.795056	<b>-1.798707</b>	-1.77726
AR(4)	-1.770056	-1.76793	-1.766721	-1.797635	-1.790862	-1.789978
AR(5)	-1.767331	-1.765414	-1.77711	-1.774808	-1.788241	-1.788561

Table 40: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 08-09 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.623366	-1.622067	-1.620245	-1.619371	-1.618159	-1.617764
AR(1)	-1.622019	-1.619324	-1.617479	-1.617837	-1.61591	-1.615689
AR(2)	-1.620151	-1.617544	-1.621645	-1.629131	-1.626408	-1.625467
AR(3)	-1.619971	-1.617576	-1.628614	-1.620488	-1.620069	-1.631772
AR(4)	-1.617911	-1.615193	-1.623938	-1.620514	-1.617915	-1.623821
AR(5)	-1.615404	-1.613003	-1.619214	-1.616214	-1.623628	<b>-1.649318</b>

Table 41: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 09-10 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.379205	-1.387215	-1.385483	-1.382875	-1.380161	-1.379189
AR(1)	-1.387969	-1.386113	-1.384542	-1.380227	-1.385384	-1.391128
AR(2)	-1.385685	-1.386163	-1.433395	-1.381585	-1.374212	-1.428074
AR(3)	-1.382991	-1.38041	-1.383311	-1.456655	-1.369713	-1.452002
AR(4)	-1.381051	-1.417641	-1.388446	-1.454521	-1.452409	-1.451449
AR(5)	-1.412297	-1.426115	-1.445344	-1.451826	-1.448885	<b>-1.462213</b>

Table 42: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 10-11 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.251933	-1.265691	-1.262943	-1.264347	-1.261954	-1.259632
AR(1)	-1.26577	-1.263007	-1.265273	-1.273747	-1.270408	-1.269451
AR(2)	-1.263006	-1.267832	-1.273115	-1.266998	-1.27604	-1.275151
AR(3)	-1.262094	-1.273836	-1.271522	-1.286206	-1.329531	-1.327723
AR(4)	-1.262224	-1.278723	-1.281032	-1.337079	-1.303448	-1.335304
AR(5)	-1.260867	-1.277803	-1.283065	-1.327699	-1.322242	<b>-1.342711</b>

Table 43: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 11-12 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.030458	-1.06977	-1.067498	-1.064743	-1.062426	-1.054768
AR(1)	-1.069073	-1.067452	-1.065972	-1.071499	-1.069657	-1.067274
AR(2)	-1.067247	-1.074383	-1.071618	-1.068874	-1.067804	-1.06297
AR(3)	-1.064651	-1.071618	-1.062182	-1.139511	-1.13588	-1.137879
AR(4)	-1.061888	-1.069052	-1.07086	-1.134516	-1.125843	-1.05265
AR(5)	-1.059786	-1.068563	-1.04838	-1.140441	-1.051449	<b>-1.144198</b>

Table 44: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 12-13 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.039856	-1.082473	-1.079819	-1.080636	-1.079277	-1.077698
AR(1)	-1.081541	-1.086415	-1.080174	-1.098352	-1.097862	-1.09536
AR(2)	-1.079167	-1.083736	-1.085919	-1.07763	-1.063188	-1.101134
AR(3)	-1.07869	-1.098665	-1.086107	-1.180936	-1.181125	-1.089063
AR(4)	-1.079643	-1.096479	-1.102236	-1.087057	-1.182132	-1.086492
AR(5)	-1.077615	-1.097718	-1.095333	-1.182033	-1.066338	<b>-1.187073</b>

Table 45: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 13-14 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.020175	-1.053766	-1.054232	-1.050031	-1.049782	-1.047358
AR(1)	-1.049365	-1.059705	-1.050039	-1.073176	-1.071351	-1.086616
AR(2)	-1.053118	-1.075803	-1.064172	-1.065101	-1.041382	-1.088549
AR(3)	-1.050424	-1.089537	-1.092691	-1.151709	-1.159553	-1.156653
AR(4)	-1.048728	-1.070964	-1.078658	-1.158018	-1.107586	-1.058326
AR(5)	-1.046222	-1.088411	-1.100879	-1.097635	-1.106819	<b>-1.172283</b>

Table 46: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 14-15 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.026434	-1.063815	-1.061998	-1.059306	-1.059512	-1.061447
AR(1)	-1.057693	-1.054924	-1.075774	-1.068943	-1.060703	-1.086278
AR(2)	-1.059974	-1.065502	-1.052026	-1.072649	-1.020857	-1.081942
AR(3)	-1.059393	-1.064486	-1.081725	-1.215973	-1.213398	<b>-1.218684</b>
AR(4)	-1.057904	-1.074473	-1.071999	-1.037552	-1.040523	-1.061865
AR(5)	-1.064037	-1.081391	-1.081189	-1.119029	-1.083128	-1.207055

Table 47: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 15-16 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.14679	-1.169437	-1.166824	-1.164349	-1.161963	-1.159387
AR(1)	-1.167297	-1.166998	-1.180225	-1.17536	-1.175681	-1.17377
AR(2)	-1.166023	-1.1796	-1.173658	-1.270186	-1.184459	-1.181882
AR(3)	-1.163582	-1.177937	-1.202752	-1.176947	-1.280798	-1.175484
AR(4)	-1.161392	-1.181529	-1.186489	-1.2808	-1.166066	-1.171225
AR(5)	-1.15984	-1.182884	-1.18556	-1.278053	-1.175627	<b>-1.300082</b>

Table 48: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 16-17 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.210322	-1.24661	-1.243988	-1.248084	-1.261023	-1.260602
AR(1)	-1.246891	-1.244299	-1.265186	-1.244784	-1.262124	-1.259969
AR(2)	-1.244244	-1.252701	-1.265333	-1.263061	-1.268549	-1.270608
AR(3)	-1.241831	-1.253971	-1.26275	-1.340448	-1.268175	-1.345049
AR(4)	-1.255066	-1.256283	-1.277107	-1.353476	-1.430224	-1.441653
AR(5)	-1.25339	-1.27165	-1.285364	-1.361418	<b>-1.441772</b>	-1.398431

Table 49: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 17-18 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.260066	-1.28611	-1.284502	-1.282644	-1.282867	-1.282745
AR(1)	-1.287607	-1.284849	-1.282191	-1.289809	-1.287331	-1.284586
AR(2)	-1.284844	-1.285735	-1.369594	-1.375481	-1.284954	-1.286692
AR(3)	-1.282078	-1.28568	-1.374396	-1.385518	-1.383002	-1.380399
AR(4)	-1.281822	-1.287215	-1.292848	-1.377162	-1.457903	-1.46443
AR(5)	-1.279242	-1.284718	-1.291947	-1.28862	-1.463661	<b>-1.476535</b>

Table 50: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 18-19 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.081561	-1.117966	-1.118316	-1.116711	-1.12467	-1.12253
AR(1)	-1.11175	-1.132212	-1.12697	-1.137594	-1.126128	-1.134853
AR(2)	-1.115681	-1.139878	-1.130529	-1.144939	-1.144703	-1.142856
AR(3)	-1.113285	-1.121255	-1.148044	<b>-1.208988</b>	-1.206392	-1.204737
AR(4)	-1.114808	-1.127717	-1.147455	-1.206346	-1.20459	-1.202045
AR(5)	-1.112081	-1.133687	-1.12952	-1.204778	-1.149791	-1.202867

Table 51: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 19-20 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.172988	-1.179242	-1.179648	-1.196896	-1.204673	-1.201939
AR(1)	-1.176531	-1.208539	-1.21395	-1.206756	-1.21249	-1.210232
AR(2)	-1.175239	-1.21315	-1.20888	-1.217073	-1.217752	-1.224067
AR(3)	-1.177668	-1.210883	-1.198644	-1.203656	-1.281386	-1.283885
AR(4)	-1.193627	-1.204242	-1.221148	-1.281194	-1.278925	-1.283049
AR(5)	-1.190871	-1.215408	-1.224004	-1.257523	-1.237741	<b>-1.290598</b>

Table 52: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 20-21 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.332395	-1.333561	-1.335768	-1.335581	-1.366365	-1.367558
AR(1)	-1.332876	-1.397513	-1.395048	-1.392846	-1.391211	-1.372883
AR(2)	-1.332876	-1.395022	-1.396057	-1.395728	-1.39402	-1.390863
AR(3)	-1.330777	-1.392812	-1.359751	-1.430101	-1.428221	-1.425776
AR(4)	-1.34685	-1.390921	-1.395074	-1.428255	-1.396653	-1.411978
AR(5)	-1.344169	-1.344874	-1.393703	-1.425824	-1.4232	<b>-1.433883</b>

Table 53: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 21-22 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.675376	-1.690984	-1.692508	-1.696202	-1.697482	-1.695124
AR(1)	-1.690039	-1.688257	-1.698859	-1.694067	-1.715948	-1.705711
AR(2)	-1.691064	-1.721858	-1.719721	-1.720564	-1.715832	-1.703028
AR(3)	-1.69296	-1.690709	-1.723452	-1.734707	-1.733628	-1.732801
AR(4)	-1.700311	-1.703695	-1.720929	-1.733619	-1.699821	-1.733082
AR(5)	-1.697608	-1.703159	-1.7058	-1.71791	-1.737796	<b>-1.748823</b>

Table 54: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 22-23 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.764985	-1.779542	-1.776873	-1.775142	-1.772688	-1.774957
AR(1)	-1.779595	-1.851975	-1.774509	-1.855452	-1.853515	-1.852747
AR(2)	-1.776859	-1.797613	-1.857636	-1.78762	-1.852136	-1.854404
AR(3)	-1.774821	-1.855569	-1.852919	-1.79111	-1.851557	-1.859033
AR(4)	-1.772219	-1.8535	-1.846317	-1.820879	-1.850049	-1.84966
AR(5)	-1.770829	-1.852283	-1.805279	-1.85084	-1.801234	<b>-1.86036</b>

Table 55: AIC values for ARMA parameters in Equation 1(Model IA) for Hour 23-24 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.415219	-1.417281	-1.414683	-1.414338	-1.418437	-1.421212
AR(1)	-1.417161	-1.453816	-1.413632	-1.45031	-1.447693	-1.445085
AR(2)	-1.414487	-1.413608	-1.423137	-1.447689	-1.444932	-1.443388
AR(3)	-1.412994	-1.45026	-1.345217	-1.442009	-1.460754	-1.455077
AR(4)	-1.41415	-1.447654	-1.446211	<b>-1.460776</b>	-1.458112	-1.458864
AR(5)	-1.414987	-1.44497	-1.443328	-1.444557	-1.449946	-1.455114

Table 56: Results of Model IA –Equation 1 and Equation 2 (2012-14)

Hours	Mean Equation				Variance Equation		
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
00-01	-0.0086 (0.1161)	(4,4)		0.0116 (0.1346)	<b>0.0007</b> (0.0000)	<b>0.2454</b> (0.0000)	<b>0.7258</b> (0.0000)
		<b>0.519</b> (0.0000)	<b>-0.6718</b> (0.0000)				
01-02	<b>-0.0163</b> (0.0002)	(4,4)		<b>0.0219</b> (0.0005)	<b>0.0006</b> (0.0000)	<b>0.236</b> (0.0000)	<b>0.7381</b> (0.0000)
		<b>0.4287</b> (0.0000)	<b>-0.5593</b> (0.0000)				
02-03	<b>-0.0181</b> (0.0005)	(1,1)		<b>0.0247</b> (0.0007)	<b>0.001</b> (0.0000)	<b>0.2595</b> (0.0000)	<b>0.6794</b> (0.0000)
		<b>0.9092</b> (0.0000)	<b>-0.9958</b> (0.0000)				
03-04	<b>-0.0213</b> (0.0001)	(5,4)		<b>0.0293</b> (0.0001)	<b>0.0012</b> (0.0000)	<b>0.238</b> (0.0000)	<b>0.6811</b> (0.0000)
		0.0637 (0.1352)	<b>-0.9344</b> (0.0000)				
04-05	<b>-0.0228</b> (0.0000)	(4,5)		<b>0.0315</b> (0.0000)	<b>0.0009</b> (0.0000)	<b>0.2409</b> (0.0000)	<b>0.7149</b> (0.0000)
		<b>0.6131</b> (0.0000)	-0.0057 (0.8683)				

Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
05-06	<b>-0.0283</b> (0.0000)	(4,2)		<b>0.0387</b> (0.0000)	<b>0.0009</b> (0.0001)	<b>0.2081</b> (0.0000)	<b>0.7239</b> (0.0000)
		<b>-0.0865</b> (0.007)	<b>-0.9894</b> (0.0000)				
06-07	<b>-0.0401</b> (0.0000)	(1,2)		<b>0.0545</b> (0.0000)	<b>0.0012</b> (0.0000)	<b>0.2487</b> (0.0000)	<b>0.6602</b> (0.0000)
		<b>0.9334</b> (0.0000)	<b>-0.0452</b> (0.0000)				
07-08	<b>-0.0435</b> (0.0000)	(3,4)		<b>0.0611</b> (0.0000)	<b>0.0007</b> (0.0000)	<b>0.2357</b> (0.0000)	<b>0.7169</b> (0.0000)
		<b>0.6637</b> (0.0000)	0.0676 (0.1753)				
08-09	<b>-0.0381</b> (0.0000)	(5,5)		<b>0.0523</b> (0.0000)	<b>0.0008</b> (0.0000)	<b>0.2492</b> (0.0000)	<b>0.7123</b> (0.0000)
		<b>0.7454</b> (0.0000)	<b>-0.8252</b> (0.0000)				
09-10	<b>-0.0424</b> (0.0000)	(5,5)		<b>0.0577</b> (0.0000)	<b>0.0006</b> (0.0000)	<b>0.1199</b> (0.0000)	<b>0.8507</b> (0.0000)
		<b>0.6508</b> (0.0000)	<b>-0.605</b> (0.0000)				
10-11	<b>-0.074</b> (0.0000)	(5,5)		<b>0.1053</b> (0.0000)	<b>0.0043</b> (0.0000)	<b>0.2073</b> (0.0000)	<b>0.5319</b> (0.0000)
		<b>0.7664</b> (0.0000)	<b>-0.8314</b> (0.0000)				
11-12	<b>-0.051</b> (0.0000)	(5,5)		<b>0.0774</b> (0.0000)	<b>0.0027</b> (0.0000)	<b>0.4272</b> (0.0000)	<b>0.5635</b> (0.0000)
		0.1975 (0.267)	<b>-0.3674</b> (0.0252)				
12-13	<b>-0.0736</b> (0.0000)	(5,5)		<b>0.1029</b> (0.0000)	<b>0.0011</b> (0.0000)	<b>0.1544</b> (0.0000)	<b>0.8027</b> (0.0000)
		<b>0.8062</b> (0.0000)	<b>-0.9023</b> (0.0000)				
13-14	<b>-0.0596</b> (0.0000)	(5,5)		<b>0.086</b> (0.0000)	<b>0.0012</b> (0.0000)	<b>0.2915</b> (0.0000)	<b>0.7114</b> (0.0000)
		<b>0.8415</b> (0.0000)	<b>-0.9546</b> (0.0000)				
14-15	<b>-0.0582</b> (0.0000)	(3,5)		<b>0.0848</b> (0.0000)	<b>0.0018</b> (0.0000)	<b>0.4004</b> (0.0000)	<b>0.611</b> (0.0000)
		<b>0.9118</b> (0.0000)	<b>0.1135</b> (0.032)				
15-16	<b>-0.0766</b> (0.0000)	(5,5)		<b>0.1069</b> (0.0000)	<b>0.0078</b> (0.0000)	<b>0.7031</b> (0.0000)	0.0707 (0.0615)
		<b>0.8905</b> (0.0000)	<b>-0.9511</b> (0.0000)				
16-17	<b>-0.1289</b>	(5,4)		<b>0.1799</b>	<b>0.0009</b>	<b>0.3801</b>	<b>0.656</b>

Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$
	(0.0000)			(0.0000)	(0.0000)	(0.0000)	(0.0000)
	<b>-0.1629</b> (0.0022)	<b>0.9362</b> (0.0000)					
17-18	<b>-0.1366</b> (0.0000)	(5,5) <b>0.8301</b> (0.0000)	<b>-0.8961</b> (0.0000)	<b>0.1904</b> (0.0000)	<b>0.0026</b> (0.0000)	<b>0.5419</b> (0.0000)	<b>0.4197</b> (0.0000)
18-19	<b>-0.0687</b> (0.0000)	(3,3) <b>0.8146</b> (0.0000)	<b>-0.9075</b> (0.0000)	<b>0.0964</b> (0.0000)	<b>0.0017</b> (0.0000)	<b>0.2812</b> (0.0000)	<b>0.6717</b> (0.0000)
19-20	<b>-0.0477</b> (0.0000)	(5,5) <b>0.7123</b> (0.0000)	<b>-0.7921</b> (0.0000)	<b>0.0671</b> (0.0000)	<b>0.001</b> (0.0002)	<b>0.5529</b> (0.0000)	<b>0.5593</b> (0.0000)
20-21	<b>-0.0375</b> (0.0000)	(5,5) <b>0.5847</b> (0.0000)	<b>-0.8091</b> (0.0000)	<b>0.0524</b> (0.0000)	<b>0.0011</b> (0.0000)	<b>0.3466</b> (0.0000)	<b>0.6602</b> (0.0000)
21-22	<b>-0.0166</b> (0.0005)	(5,5) <b>0.6261</b> (0.0000)	<b>-0.7415</b> (0.0000)	<b>0.0233</b> (0.0006)	<b>0.0004</b> (0.0000)	<b>0.3686</b> (0.0000)	<b>0.6788</b> (0.0000)
22-23	<b>-0.0107</b> (0.0005)	(5,5) <b>0.5082</b> (0.0000)	<b>-0.5936</b> (0.0000)	<b>0.0144</b> (0.0009)	<b>0.0002</b> (0.0000)	<b>0.8422</b> (0.0000)	<b>0.4787</b> (0.0000)
23-24	<b>-0.0235</b> (0.0000)	(4,3) 0.0124 (0.7943)	<b>-0.8865</b> (0.0000)	<b>0.0326</b> (0.0000)	<b>0.0006</b> (0.0000)	<b>0.2302</b> (0.0000)	<b>0.7608</b> (0.0000)

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

For the second set of period (1 April 2012 to 31 March 2014), with respect to the weekday effect, the coefficient of dummy variable ( $\beta_2$ ) in the mean equation (Equation 1) is found to be positive and significant for twenty three hours out of the twenty four hours (insignificant for one hour; 00-01). The positive sign indicates that the price returns tend to be higher on weekdays as the prices are found to be higher on weekdays compared to weekends. The coefficient of ARCH effect ( $\beta_4$ ) in variance equation (Equation 2) is found to be significant for all the twenty four hours. The coefficient of GARCH effect ( $\beta_5$ ) in the variance equation (Equation 2) is able to explain the volatility in returns for twenty three hours out of the twenty four hours. The coefficient of GARCH effect is found to be insignificant in case of one hour (15-16).

## Model IB



In Model IB, we assess the impact of weekday effect ( $\beta_2$ ) on current return and volatility of return using a dummy variable (1-weekdays; 0-weekend) with a ARMA GARCH model for each hour separately for the two sets of periods. For each hour, we calculate AIC values using different orders of ARMA in ARMA GARCH model. The AIC values for ARMA parameters in Equation 1 (Model IB) are reported for hours in Table 57 to Table 80 for 2010-12. Table 81 reports the results of the estimation for the period 2010-12.

**Table 57: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 00-01 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.755323	-2.753489	-2.751015	-2.757743	-2.767088	-2.778392
AR(1)	-2.753625	-2.752138	-2.754845	-2.784322	-2.782166	-2.78021
AR(2)	-2.750826	-2.780947	-2.772935	-2.787126	-2.784917	-2.783133
AR(3)	-2.757812	-2.785695	-2.785282	-2.784283	-2.790688	<b>-2.806832</b>
AR(4)	-2.763943	-2.783044	-2.780674	-2.778227	-2.786162	-2.789964
AR(5)	-2.771259	-2.780248	-2.771777	-2.790861	-2.804437	-2.802277

**Table 58: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 01-02 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.85752	-2.857753	-2.856961	-2.855933	-2.875334	-2.881036
AR(1)	-2.857919	-2.878803	-2.87795	-2.900788	-2.901504	-2.89879
AR(2)	-2.855789	-2.841462	-2.866806	-2.903163	-2.912461	-2.904956
AR(3)	-2.857729	-2.901914	-2.902076	-2.906788	-2.911212	-2.908594
AR(4)	-2.871241	-2.900386	-2.913893	-2.914974	-2.916464	-2.91293
AR(5)	-2.882906	-2.899535	-2.911616	-2.916578	-2.915374	<b>-2.924354</b>

**Table 59: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 02-03 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.942671	-2.940185	-2.937323	-2.938635	-2.953827	-2.956438
AR(1)	-2.94016	-2.945404	-2.942716	-2.968523	-2.96689	-2.964267
AR(2)	-2.937291	-2.942714	-2.939374	-2.97156	-2.971902	-2.969571
AR(3)	-2.937637	-2.969548	-2.950715	-2.961958	-2.96039	-2.970199
AR(4)	-2.94475	-2.968402	-2.973169	-2.981179	-2.968169	-2.96829
AR(5)	-2.948501	-2.965663	-2.964988	-2.974136	<b>-3.007061</b>	-2.971815

**Table 60: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 03-04 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-3.026549	-3.024045	-3.028426	-3.027134	-3.034012	-3.0374
AR(1)	-3.023993	-3.021163	<b>-3.048639</b>	-3.04331	-3.040582	-3.034824
AR(2)	-3.0258	-3.047689	-3.04754	-3.034607	-3.042156	-3.034411
AR(3)	-3.025847	-3.044827	-3.045193	-3.042517	-3.039673	-3.039758
AR(4)	-3.031388	-3.04202	-3.042407	-3.039646	-3.036807	-3.039124
AR(5)	-3.032341	-3.047842	-3.038877	-3.03866	-3.038728	-3.026402

**Table 61: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 04-05 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.947498	-2.945035	-2.893317	-2.911792	-2.91298	-2.917369
AR(1)	-2.94495	-2.896477	-2.939901	-2.921552	-2.969254	-2.922239
AR(2)	-2.942147	-2.967244	-2.966331	-2.921728	-2.931155	-2.932191
AR(3)	-2.87319	-2.934195	-2.53928	-2.967336	-2.913665	-2.927496
AR(4)	-2.955784	<b>-2.969267</b>	-2.919168	-2.933725	-2.922621	-2.959656
AR(5)	-2.909216	-2.674199	-2.924123	-2.92811	-2.919819	-2.924805

**Table 62: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 05-06 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.924858	-2.925143	-2.922248	-2.929714	-2.974912	-2.97958
AR(1)	-2.925273	-2.922828	-2.921627	-2.96981	-2.979528	-2.977429
AR(2)	-2.92239	-2.921507	-2.93982	-2.981127	-2.97776	-2.98003
AR(3)	-2.922317	-2.97186	-2.978455	-2.981439	-2.98049	-2.98127
AR(4)	-2.957847	-2.979328	-2.97896	-2.977538	-2.985382	-2.981188
AR(5)	-2.963655	-2.980345	-2.977842	-2.974931	-2.982481	<b>-2.990847</b>

**Table 63: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 06-07 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-3.134879	-3.133807	-3.135343	-3.138226	-3.154094	-3.155557
AR(1)	-3.134067	-3.130267	-3.133601	-3.169029	-3.167378	-3.164867
AR(2)	-3.1332	-3.131773	-3.137806	-3.167088	-3.168577	-3.165645
AR(3)	-3.138552	-3.168168	-3.165244	-3.165852	-3.165768	-3.16416
AR(4)	-3.148766	-3.165249	-3.16714	-3.166433	-3.163552	-3.161305
AR(5)	-3.146284	-3.165091	-3.165553	<b>-3.175467</b>	-3.162535	-3.168697

**Table 64: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 07-08 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.98947	-2.991026	-2.990706	-2.993067	-3.013033	-3.015248
AR(1)	-2.990589	-2.993225	-2.990563	-3.023078	-3.024096	-3.021375
AR(2)	-2.990702	-3.025696	-3.024369	-3.021543	-3.024705	-3.021898
AR(3)	-2.99156	-3.024085	-3.021528	-2.998773	-3.022129	-3.025395
AR(4)	-3.005522	-3.022625	-3.025209	-3.029944	-3.028838	-3.014048
AR(5)	-3.007054	-3.021488	-3.022557	-3.024853	-3.016196	<b>-3.030552</b>

**Table 65: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 08-09 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.983223	-2.980829	-2.978378	-2.979667	-2.996805	-3.010374
AR(1)	-2.980813	-2.978591	-3.006903	-3.008374	-3.012704	-3.011643
AR(2)	-2.978371	-3.00829	-3.010668	-2.995351	-3.010808	-3.00892
AR(3)	-2.978482	-3.010305	-3.008762	-2.99826	-3.010313	-3.007492
AR(4)	-2.991092	-3.010088	-3.007375	-3.01029	-3.007666	-3.007667
AR(5)	-3.000983	-3.007903	-3.006145	<b>-3.013952</b>	-3.00495	-2.990946

**Table 66: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 09-10 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.849216	-2.848126	-2.845385	-2.845229	-2.853173	-2.860448
AR(1)	-2.848131	-2.861044	-2.858854	-2.858621	-2.860252	-2.858993
AR(2)	-2.845324	-2.858937	-2.859471	-2.858124	-2.858176	-2.856303
AR(3)	-2.84313	-2.859084	-2.858361	-2.853486	-2.86697	-2.864871
AR(4)	-2.847214	-2.858924	-2.856215	-2.852728	-2.854474	-2.866807
AR(5)	-2.85371	-2.856096	-2.836053	-2.863888	-2.866428	<b>-2.867448</b>

Table 67: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 10-11 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.712554	-2.725083	-2.72303	-2.7337	-2.7466	-2.757013
AR(1)	-2.724169	-2.76505	-2.763151	-2.764194	-2.764367	-2.761699
AR(2)	-2.721539	-2.76339	-2.762107	-2.762021	-2.761559	-2.758881
AR(3)	-2.721347	-2.763621	-2.760343	<b>-2.807387</b>	-2.760909	-2.781905
AR(4)	-2.728985	-2.761894	-2.763875	-2.805214	-2.765352	-2.797746
AR(5)	-2.738369	-2.760404	-2.73696	-2.800313	-2.798584	-2.760143

Table 68: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 11-12 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.658671	-2.668781	-2.665995	-2.692638	-2.695244	-2.719078
AR(1)	-2.668941	-2.709432	-2.707126	-2.71666	-2.714019	-2.722568
AR(2)	-2.666764	-2.681975	-2.703909	-2.71491	-2.711408	-2.728769
AR(3)	-2.676976	-2.694971	-2.714828	-2.714682	-2.752521	-2.72793
AR(4)	-2.681572	-2.714828	-2.712568	-2.752607	-2.727815	-2.726969
AR(5)	-2.69271	-2.712172	-2.711256	-2.735934	-2.733142	<b>-2.798996</b>

Table 69: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 12-13 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.585323	-2.596444	-2.595594	-2.620502	-2.62641	-2.649126
AR(1)	-2.598062	-2.640061	-2.603669	-2.655997	-2.653222	-2.652747
AR(2)	-2.599633	-2.638898	-2.642798	-2.653323	-2.650599	-2.651054
AR(3)	-2.610481	-2.655319	-2.652752	-2.70576	-2.66007	-2.667286
AR(4)	-2.620187	-2.652916	-2.650965	-2.704153	-2.641542	-2.665408
AR(5)	-2.629173	-2.651823	-2.63943	-2.677179	-2.674689	<b>-2.722733</b>

Table 70: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 13-14 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.625959	-2.633349	-2.636403	-2.655965	-2.654912	-2.672492
AR(1)	-2.635461	-2.665846	-2.664699	-2.680113	-2.678629	-2.677608
AR(2)	-2.640399	-2.642312	-2.670664	-2.67952	-2.678241	-2.677496
AR(3)	-2.649383	-2.6807	-2.678562	-2.722508	-2.72199	-2.687328
AR(4)	-2.655006	-2.679117	-2.680677	-2.722863	-2.727682	-2.686033
AR(5)	-2.656703	-2.677645	-2.687958	-2.686921	-2.684267	<b>-2.785776</b>

Table 71: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 14-15(Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.521917	-2.539323	-2.537219	-2.574355	-2.588347	-2.601381
AR(1)	-2.539152	-2.592628	-2.591041	-2.610111	-2.607505	-2.605391
AR(2)	-2.53673	-2.591668	-2.587914	-2.607444	-2.604686	-2.60617
AR(3)	-2.546156	-2.605643	-2.603069	-2.605967	-2.672347	-2.623973
AR(4)	-2.567209	-2.603452	-2.606712	-2.672493	-2.670502	-2.703979
AR(5)	-2.575517	-2.611251	-2.611002	-2.705407	-2.634626	<b>-2.736654</b>

Table 72: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 15-16 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.455606	-2.474452	-2.473063	-2.505864	-2.513852	-2.530686
AR(1)	-2.473842	-2.525299	-2.524151	-2.536062	-2.53336	-2.531945
AR(2)	-2.471112	-2.524833	-2.527002	-2.514404	-2.479898	-2.529567
AR(3)	-2.480562	-2.533932	-2.531248	-2.522677	-2.607303	-2.571348
AR(4)	-2.495555	-2.531487	-2.528424	-2.60583	-2.531549	-2.601144
AR(5)	-2.50578	-2.533203	-2.561863	-2.541347	-2.599389	<b>-2.626632</b>

Table 73: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 16-17 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.404009	-2.420739	-2.418983	-2.443534	-2.453431	-2.476938
AR(1)	-2.421665	-2.421772	-2.419469	-2.486176	-2.483357	-2.480837
AR(2)	-2.422195	-2.419802	-2.408743	-2.483356	-2.488496	-2.496159
AR(3)	-2.427651	-2.476626	-2.508967	-2.571412	-2.485516	-2.492158
AR(4)	-2.456735	-2.466073	-2.494265	-2.507016	-2.528517	-2.536449
AR(5)	-2.459346	-2.492459	-2.521635	-2.506556	-2.535855	<b>-2.626942</b>

Table 74: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 17-18 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.400277	-2.435856	-2.433235	-2.441747	-2.44848	-2.455744
AR(1)	-2.437189	-2.434656	-2.432105	-2.507212	-2.504449	-2.507823
AR(2)	-2.434579	-2.459208	-2.453061	-2.504386	-2.543812	-2.515058
AR(3)	-2.433104	-2.503143	-2.500314	-2.503594	-2.406615	-2.566693
AR(4)	-2.441992	-2.500327	-2.567222	-2.496506	-2.483254	-2.44553
AR(5)	-2.442011	-2.508267	-2.508571	-2.492902	<b>-2.627005</b>	-2.612197

Table 75: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 18-19 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.628081	-2.66207	-2.659609	-2.680779	-2.695798	-2.718985
AR(1)	-2.664534	-2.662789	-2.660253	-2.729886	-2.728137	-2.718175
AR(2)	-2.662352	-2.72252	-2.725488	-2.727582	-2.728336	-2.716123
AR(3)	-2.664032	-2.728495	-2.725716	-2.777062	-2.776546	-2.729298
AR(4)	-2.677069	-2.725734	-2.7257	-2.776946	-2.732493	-2.735781
AR(5)	-2.683745	-2.731138	-2.728065	-2.736763	-2.727572	<b>-2.788633</b>

Table 76: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 19-20 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.560362	-2.581616	-2.579572	-2.596143	-2.605226	-2.627564
AR(1)	-2.580691	-2.634398	-2.577325	-2.641188	-2.636275	-2.641677
AR(2)	-2.578003	-2.577681	-2.642227	-2.637555	-2.653343	-2.635685
AR(3)	-2.580286	-2.642044	-2.639523	-2.743828	-2.678575	-2.642169
AR(4)	-2.587086	-2.639448	-2.641201	-2.74201	-2.649988	-2.64079
AR(5)	-2.593063	-2.639695	-2.643653	-2.649417	-2.655795	<b>-2.7496</b>

Table 77: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 20-21 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.660291	-2.672029	-2.674679	-2.686604	-2.70093	-2.711482
AR(1)	-2.67027	-2.723061	-2.720429	-2.718611	-2.7166	-2.714518
AR(2)	-2.671835	-2.720367	-2.72536	-2.723263	-2.723066	-2.712574
AR(3)	-2.673587	-2.717306	-2.723337	-2.723849	-2.718848	-2.722217
AR(4)	-2.678193	-2.716625	-2.716422	-2.726242	-2.770869	-2.724018
AR(5)	-2.688085	-2.716084	-2.715352	-2.722225	-2.725727	<b>-2.771849</b>

Table 78: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 21-22 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.833477	-2.836784	-2.838405	-2.85004	-2.862845	-2.868194
AR(1)	-2.836043	-2.877735	-2.875585	-2.87792	-2.875929	-2.874819
AR(2)	-2.83527	-2.875768	-2.881218	-2.879814	-2.880574	-2.86675
AR(3)	-2.838092	-2.879489	-2.863035	-2.883361	-2.878045	-2.876322
AR(4)	-2.845122	-2.877515	-2.877109	<b>-2.90539</b>	-2.878015	-2.862576
AR(5)	-2.848516	-2.875216	-2.874246	-2.876652	-2.871511	-2.876607

Table 79: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 22-23 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.929645	-2.927548	-2.926771	-2.946115	-2.950109	-2.952391
AR(1)	-2.927456	-2.96181	-2.959033	-2.961899	-2.959457	-2.957442
AR(2)	-2.925411	-2.959021	-2.972929	-2.959981	-2.97569	-2.973505
AR(3)	-2.935256	-2.962465	-2.960144	-2.958279	-2.957131	-2.980972
AR(4)	-2.935173	-2.961224	-2.975349	-2.957466	-2.958354	-2.97019
AR(5)	-2.936021	-2.958381	<b>-2.993921</b>	-2.98116	-2.968753	-2.9714

Table 80: AIC values for ARMA parameters in Equation 1(Model IB) for Hour 23-24 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.819092	-2.81692	-2.818821	-2.834163	-2.848762	-2.848615
AR(1)	-2.816848	-2.860255	-2.813948	-2.860062	-2.857418	-2.855099
AR(2)	-2.816466	-2.861592	-2.859826	-2.858646	-2.857823	-2.85591
AR(3)	-2.820973	-2.813384	-2.857324	-2.854772	<b>-2.89473</b>	-2.891991
AR(4)	-2.829473	-2.857245	-2.857497	-2.894716	-2.891988	-2.847312
AR(5)	-2.830225	-2.855263	-2.856961	-2.869695	-2.871542	-2.877877

Table 81: Results of Model IB -Equation 1 and Equation 3 (2010-12)

Hours	Mean Equation	Variance Equation
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	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
00-01	<b>-0.0112</b> <b>(0.0058)</b>	(3,5)		<b>0.0163</b> <b>(0.0024)</b>	<b>0.0025</b> <b>(0.0000)</b>	<b>0.399</b> <b>(0.0000)</b>	<b>0.1858</b> <b>(0.0032)</b>	<b>-0.001</b> <b>(0.0000)</b>
		<b>0.7099</b> <b>(0.0000)</b>	<b>-0.1054</b> <b>(0.0119)</b>					
01-02	<b>-0.0152</b> <b>(0.0000)</b>	(5,5)		<b>0.0214</b> <b>(0.0000)</b>	<b>0.0023</b> <b>(0.0000)</b>	<b>0.4751</b> <b>(0.0000)</b>	-0.0324 <b>(0.2519)</b>	-0.0003 <b>(0.15)</b>
		<b>0.7395</b> <b>(0.0000)</b>	<b>-0.6901</b> <b>(0.0000)</b>					
02-03	<b>-0.0158</b> <b>(0.0000)</b>	(5,4)		<b>0.0223</b> <b>(0.0000)</b>	<b>0.0025</b> <b>(0.0000)</b>	<b>0.3352</b> <b>(0.0000)</b>	<b>-0.1518</b> <b>(0.0000)</b>	-2.01E-05 <b>(0.9264)</b>
		0.0492 <b>(0.2134)</b>	<b>-0.7403</b> <b>(0.0000)</b>					
03-04	<b>-0.0151</b> <b>(0.0000)</b>	(1,2)		<b>0.0214</b> <b>(0.0000)</b>	<b>0.0018</b> <b>(0.0000)</b>	<b>0.3274</b> <b>(0.0000)</b>	-0.0073 <b>(0.933)</b>	0.0003 <b>(0.116)</b>
		<b>0.9326</b> <b>(0.0000)</b>	-0.0739 <b>(0.1139)</b>					
04-05	<b>-0.0161</b> <b>(0.0000)</b>	(4,1)		<b>0.0218</b> <b>(0.0000)</b>	<b>0.0024</b> <b>(0.0000)</b>	<b>0.2433</b> <b>(0.0000)</b>	-0.0468 <b>(0.7052)</b>	4.85E-05 <b>(0.8469)</b>
		0.0629 <b>(0.0984)</b>	<b>-0.9624</b> <b>(0.0000)</b>					
05-06	<b>-0.016</b> <b>(0.0000)</b>	(5,5)		<b>0.0212</b> <b>(0.0000)</b>	<b>0.0005</b> <b>(0.0052)</b>	<b>0.2563</b> <b>(0.0000)</b>	<b>0.5757</b> <b>(0.0000)</b>	0.0001 <b>(0.5746)</b>
		<b>0.5175</b> <b>(0.0000)</b>	<b>-0.758</b> <b>(0.0000)</b>					
06-07	<b>-0.0188</b> <b>(0.0000)</b>	(5,3)		<b>0.026</b> <b>(0.0000)</b>	<b>0.001</b> <b>(0.0000)</b>	<b>0.2859</b> <b>(0.0000)</b>	<b>0.4145</b> <b>(0.0000)</b>	<b>-0.0003</b> <b>(0.0256)</b>
		<b>-0.1102</b> <b>(0.0124)</b>	<b>-0.8266</b> <b>(0.0000)</b>					
07-08	<b>-0.0186</b> <b>(0.0000)</b>	(5,5)		<b>0.0262</b> <b>(0.0000)</b>	<b>0.0004</b> <b>(0.0026)</b>	<b>0.0209</b> <b>(0.0477)</b>	<b>0.8915</b> <b>(0.0000)</b>	-0.0003 <b>(0.0691)</b>
		<b>0.5564</b> <b>(0.0000)</b>	<b>-0.4504</b> <b>(0.0000)</b>					
08-09	<b>-0.0238</b> <b>(0.0000)</b>	(5,3)		<b>0.0331</b> <b>(0.0000)</b>	<b>0.002</b> <b>(0.0000)</b>	<b>0.2957</b> <b>(0.0000)</b>	0.1613 <b>(0.1112)</b>	<b>-0.0005</b> <b>(0.0182)</b>
		-0.0811 <b>(0.0754)</b>	<b>-0.8848</b> <b>(0.0000)</b>					
09-10	<b>-0.0261</b> <b>(0.0000)</b>	(5,5)		<b>0.0361</b> <b>(0.0000)</b>	<b>0.0021</b> <b>(0.0000)</b>	<b>0.2451</b> <b>(0.0000)</b>	<b>0.4328</b> <b>(0.0000)</b>	<b>-0.0013</b> <b>(0.0000)</b>
		<b>0.4919</b> <b>(0.0004)</b>	<b>-0.6443</b> <b>(0.0000)</b>					
10-11	<b>-0.029</b> <b>(0.0000)</b>	(3,3)		<b>0.0404</b> <b>(0.0000)</b>	<b>0.0023</b> <b>(0.0000)</b>	<b>0.5011</b> <b>(0.0000)</b>	<b>0.2292</b> <b>(0.0000)</b>	<b>-0.0012</b> <b>(0.0000)</b>
		<b>0.8063</b> <b>(0.0000)</b>	<b>-0.8986</b> <b>(0.0000)</b>					
11-12	<b>-0.0476</b> <b>(0.0000)</b>	(5,5)		<b>0.0665</b> <b>(0.0000)</b>	<b>0.0026</b> <b>(0.0000)</b>	<b>0.3563</b> <b>(0.0000)</b>	<b>0.3154</b> <b>(0.0000)</b>	<b>-0.0017</b> <b>(0.0000)</b>
		<b>0.8062</b> <b>(0.0000)</b>	<b>-0.8507</b> <b>(0.0000)</b>					
12-13	<b>-0.0434</b> <b>(0.0000)</b>	(5,5)		<b>0.0609</b> <b>(0.0000)</b>	<b>0.0017</b> <b>(0.0000)</b>	<b>0.4786</b> <b>(0.0000)</b>	<b>0.3764</b> <b>(0.0000)</b>	<b>-0.001</b> <b>(0.0002)</b>
		<b>0.7901</b> <b>(0.0000)</b>	<b>-0.8314</b> <b>(0.0000)</b>					
13-14	<b>-0.0526</b>	(5,5)		<b>0.0738</b>	<b>0.002</b>	<b>0.5182</b>	<b>0.24</b>	<b>-0.0009</b>

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
	(0.0000)			(0.0000)	(0.0000)	(0.0000)	(0.0002)	(0.0022)
		<b>0.8771</b> (0.0000)	<b>-0.8871</b> (0.0000)					
14-15	<b>-0.0579</b> (0.0000)	(5,5)		<b>0.0805</b> (0.0000)	<b>0.0025</b> (0.0000)	<b>0.3865</b> (0.0000)	<b>0.4203</b> (0.0000)	<b>-0.0019</b> (0.0000)
		<b>0.7807</b> (0.0000)	<b>-0.8731</b> (0.0000)					
15-16	<b>-0.0367</b> (0.0000)	(5,5)		<b>0.0499</b> (0.0000)	<b>0.0015</b> (0.0000)	<b>0.2857</b> (0.0000)	<b>0.6681</b> (0.0000)	<b>-0.0015</b> (0.0000)
		<b>0.7392</b> (0.0000)	<b>-0.9087</b> (0.0000)					
16-17	<b>-0.0593</b> (0.0000)	(5,5)		<b>0.0827</b> (0.0000)	<b>0.0011</b> (0.0000)	<b>0.3959</b> (0.0000)	<b>0.4784</b> (0.0000)	-0.0002 (0.1757)
		<b>0.8529</b> (0.0000)	<b>-0.8202</b> (0.0000)					
17-18	<b>-0.0399</b> (0.0000)	(5,4)		<b>0.0559</b> (0.0000)	<b>0.0013</b> (0.0000)	<b>1.0233</b> (0.0000)	0.0435 (0.2188)	0.0003 (0.2438)
		<b>0.2505</b> (0.0000)	<b>-0.8262</b> (0.0000)					
18-19	<b>-0.0334</b> (0.0000)	(5,5)		<b>0.0463</b> (0.0000)	<b>0.0007</b> (0.001)	<b>0.4167</b> (0.0000)	<b>0.4975</b> (0.0000)	-0.0002 (0.431)
		<b>0.6764</b> (0.0000)	<b>-0.8245</b> (0.0000)					
19-20	<b>-0.0309</b> (0.0000)	(5,5)		<b>0.0432</b> (0.0000)	<b>0.0017</b> (0.0000)	<b>0.5711</b> (0.0000)	<b>0.2104</b> (0.0000)	-0.0004 (0.0854)
		<b>0.6493</b> (0.0000)	<b>-0.8089</b> (0.0000)					
20-21	<b>-0.0513</b> (0.0000)	(5,5)		<b>0.0714</b> (0.0000)	<b>0.001</b> (0.0003)	<b>0.1657</b> (0.0001)	<b>0.6309</b> (0.0000)	-0.0003 (0.2281)
		<b>0.7348</b> (0.0000)	<b>-0.9216</b> (0.0000)					
21-22	<b>-0.0258</b> (0.0000)	(4,3)		<b>0.0358</b> (0.0000)	<b>0.0005</b> (0.0427)	<b>0.1261</b> (0.0002)	<b>0.6857</b> (0.0000)	9.79E-05 (0.6817)
		<b>-0.1061</b> (0.0268)	<b>-0.8737</b> (0.0000)					
22-23	<b>-0.0239</b> (0.0000)	(4,2)		<b>0.0334</b> (0.0000)	<b>0.0006</b> (0.0055)	<b>0.207</b> (0.0000)	<b>0.5461</b> (0.0000)	0.0001 (0.466)
		0.0202 (0.6331)	<b>-0.9002</b> (0.0000)					
23-24	<b>-0.0163</b> (0.0000)	(3,4)		<b>0.0222</b> (0.0000)	0.0003 (0.1748)	<b>0.2329</b> (0.0000)	<b>0.5539</b> (0.0000)	<b>0.0006</b> (0.0034)
		<b>0.7762</b> (0.0000)	<b>-0.1074</b> (0.031)					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

In the period 1 April 2010 to 31 March 2012, on estimation of Model IB (Equation 1 and Equation 3, with respect to the weekday effect on the current return it is observed that the coefficient of dummy variable ( $\beta_2$ ) in the mean equation (Equation 1) is found to be positive and

significant for all the twenty four hours. The coefficients of ARCH effect ( $\beta_4$ ) in variance equation (Equation 3) are found to be significant for all the twenty four hours. The coefficient of GARCH effect ( $\beta_5$ ) in the variance equation (Equation 3) is able to explain the volatility in returns. GARCH effect is found to be insignificant only in case of five hours out of the twenty four hours (01-02, 03-04, 04-05, 08-09, 17-18). With respect to the weekday effect on the return volatility it is observed that the coefficient of dummy variable ( $\beta_6$ ) in the variance equation (Equation 3) is found to be significant for eleven hours out of the twenty four hours (00-01, 06-07, 08-09, 09-10, 10-11,11-12,12-13,13-14,14-15,15-16,23-24) indicating that volatility is higher on weekdays whereas the coefficient of dummy variable ( $\beta_6$ ) is insignificant in case of thirteen hours out of the twenty hours.

The AIC values for ARMA parameters in mean equation (Equation 1 of Model IB) are reported for the twenty four hours in Table 82 to Table 105 for 2012-14. Table 106 reports the results of the estimation for the period 2012-14.

**Table 82: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 00-01 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.577923	-1.575579	-1.577933	-1.579258	-1.584017	-1.582412
AR(1)	-1.57542	-1.627175	-1.580508	-1.578265	-1.631077	-1.627434
AR(2)	-1.576771	-1.580376	-1.628686	-1.626376	-1.629461	-1.588389
AR(3)	-1.579382	-1.578999	-1.626588	-1.632658	-1.630079	-1.625673
AR(4)	-1.585897	-1.631992	-1.632292	-1.631277	-1.629496	-1.619189
AR(5)	-1.583132	-1.631092	-1.617612	-1.620948	-1.624114	<b>-1.642234</b>

**Table 83: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 01-02 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.621641	-1.619049	-1.617708	-1.6159	-1.619354	-1.617479
AR(1)	-1.619056	-1.655162	-1.616214	-1.614395	-1.652921	-1.651543
AR(2)	-1.617501	-1.65331	-1.651312	-1.648799	-1.651873	-1.612125
AR(3)	-1.616441	-1.612313	-1.648831	-1.638179	-1.651342	-1.651988
AR(4)	-1.621133	-1.654202	<b>-1.672345</b>	-1.669833	-1.667526	-1.664645
AR(5)	-1.618974	-1.614374	-1.612351	-1.65011	-1.66466	-1.663931

**Table 84: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 02-03 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.653862	-1.652759	-1.655647	-1.652978	-1.659258	-1.659146
AR(1)	-1.652143	<b>-1.714144</b>	-1.70117	-1.70435	-1.707327	-1.705879
AR(2)	-1.654528	-1.711674	-1.712847	-1.706986	-1.705137	-1.703455
AR(3)	-1.651776	-1.709246	-1.706998	-1.644581	-1.711049	-1.712765
AR(4)	-1.653852	-1.70743	-1.705318	-1.712024	-1.711745	-1.706415
AR(5)	-1.651536	-1.705974	-1.703562	-1.712655	-1.706611	-1.702999



**Table 85: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 03-04 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.607226	-1.611025	-1.609542	-1.607756	-1.606346	-1.603655
AR(1)	-1.609642	-1.645335	-1.643674	-1.637229	-1.634842	-1.634602
AR(2)	-1.608307	-1.643705	-1.65156	-1.615237	-1.633795	-1.60972
AR(3)	-1.606898	-1.640967	-1.647964	-1.623111	-1.632293	-1.638767
AR(4)	-1.604742	-1.638228	-1.626929	-1.63648	-1.636663	<b>-1.654056</b>
AR(5)	-1.602603	-1.635483	-1.609344	-1.644069	-1.637816	-1.653816

**Table 86: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 04-05 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.538203	-1.538031	-1.549212	-1.546504	-1.546315	-1.543553
AR(1)	-1.536752	-1.578396	-1.575765	-1.578458	-1.578433	-1.574893
AR(2)	-1.548163	-1.575753	-1.581494	-1.581869	-1.575533	-1.570659
AR(3)	-1.54542	-1.579399	-1.577167	-1.574692	-1.580642	-1.531123
AR(4)	-1.543244	-1.577531	-1.574351	-1.571763	<b>-1.596608</b>	-1.59407
AR(5)	-1.540684	-1.574796	-1.570726	-1.543204	-1.585587	-1.58331

**Table 87: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 05-06 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.628604	-1.629006	-1.626563	-1.625608	-1.627002	-1.626055
AR(1)	-1.628836	-1.679209	-1.676499	-1.626437	-1.678459	-1.675798
AR(2)	-1.626709	-1.676504	-1.677384	-1.628753	-1.675626	-1.675472
AR(3)	-1.625771	-1.626391	<b>-1.692387</b>	-1.642169	-1.673872	-1.672817
AR(4)	-1.626457	-1.678536	-1.675938	-1.673866	-1.672925	-1.673539
AR(5)	-1.623928	-1.675948	-1.675341	-1.631823	-1.638153	-1.667027

**Table 88: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 06-07 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.694877	-1.692189	-1.691402	-1.690577	-1.687842	-1.689677
AR(1)	-1.692181	-1.720334	-1.71752	-1.716533	-1.712269	-1.710253
AR(2)	-1.69143	-1.717525	<b>-1.745712</b>	-1.712087	-1.707797	-1.707517
AR(3)	-1.68983	-1.693053	-1.715447	-1.713756	-1.707836	-1.724325
AR(4)	-1.687074	-1.691541	-1.739985	-1.712738	-1.728146	-1.706707
AR(5)	-1.688148	-1.710205	-1.708955	-1.715695	-1.708944	-1.729913

**Table 89: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 07-08 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.77165	-1.769586	-1.769578	-1.773278	-1.77087	-1.768104
AR(1)	-1.769344	-1.799495	-1.79608	-1.77053	-1.768382	-1.795186
AR(2)	-1.769085	-1.797269	-1.771525	-1.783304	-1.781186	-1.780111
AR(3)	-1.772887	-1.770331	-1.783107	<b>-1.813094</b>	-1.770984	-1.777441
AR(4)	-1.770802	-1.793306	-1.767261	-1.806063	-1.803682	-1.794031
AR(5)	-1.768059	-1.766474	-1.778047	-1.775661	-1.79268	-1.811062

**Table 90: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 08-09 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.6206	-1.619301	-1.617505	-1.616647	-1.615465	-1.614999
AR(1)	-1.619253	-1.61656	-1.614739	-1.615107	-1.613193	-1.612925
AR(2)	-1.617404	-1.61482	-1.618879	-1.631342	-1.623248	-1.622741
AR(3)	-1.617252	-1.614851	-1.612087	-1.617723	-1.617304	-1.624653
AR(4)	-1.61522	-1.612494	-1.623488	-1.62592	-1.62159	-1.626062
AR(5)	-1.612705	-1.610311	-1.616142	-1.629161	-1.622838	<b>-1.633892</b>

Table 91: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 09-10 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.415385	-1.426091	-1.423345	-1.424211	-1.422461	-1.423862
AR(1)	-1.42646	-1.424365	-1.422858	-1.422018	-1.425468	-1.434049
AR(2)	-1.423773	-1.422399	-1.421689	-1.418942	-1.45345	-1.454679
AR(3)	-1.424452	-1.421717	-1.419096	-1.465062	-1.462553	-1.460129
AR(4)	-1.422675	-1.43514	-1.453934	-1.462447	-1.461811	-1.459108
AR(5)	-1.432902	-1.444213	-1.441421	-1.460049	-1.457094	<b>-1.469618</b>

Table 92: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 10-11 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.314137	-1.329664	-1.327125	-1.327722	-1.324966	-1.322228
AR(1)	-1.328841	-1.338551	-1.327425	-1.340783	-1.339317	-1.330085
AR(2)	-1.326436	-1.327903	-1.339413	-1.338292	-1.340842	-1.34216
AR(3)	-1.326411	-1.341278	-1.339513	-1.35792	-1.382696	-1.36164
AR(4)	-1.324703	-1.335667	-1.343399	-1.382331	-1.380401	-1.378757
AR(5)	-1.32293	-1.334725	-1.34738	-1.369866	-1.380923	<b>-1.384428</b>

Table 93: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 11-12 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.193956	-1.223991	-1.222854	-1.220106	-1.21842	-1.215655
AR(1)	-1.219015	-1.222936	-1.22017	-1.219751	-1.215907	-1.221801
AR(2)	-1.221424	-1.220198	-1.219361	-1.227659	-1.221677	-1.210455
AR(3)	-1.220568	-1.218942	-1.223301	-1.214586	-1.116159	-1.223495
AR(4)	-1.217874	-1.215085	-1.220998	-1.236936	-1.234095	-1.226716
AR(5)	-1.215108	-1.221345	-1.220574	-1.218377	-1.218603	<b>-1.241228</b>

Table 94: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 12-13 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.164378	-1.196254	-1.196179	-1.199694	-1.197153	-1.194728
AR(1)	-1.191421	-1.199931	-1.196647	-1.21792	-1.216059	-1.215823
AR(2)	-1.191254	-1.220803	-1.220021	-1.214911	-1.213386	-1.214013
AR(3)	-1.194488	-1.218571	-1.217471	-1.241678	-1.189919	-1.187298
AR(4)	-1.198331	-1.207885	-1.213943	-1.257348	-1.196474	-1.231952
AR(5)	-1.19616	-1.212712	-1.217006	-1.262895	-1.216736	<b>-1.267665</b>

Table 95: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 13-14 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.127577	-1.159614	-1.158384	-1.15565	-1.153159	-1.150496
AR(1)	-1.154283	-1.158677	-1.161921	-1.159229	-1.173375	-1.168322
AR(2)	-1.156935	-1.179867	-1.159174	-1.178234	-1.173414	-1.175057
AR(3)	-1.154784	-1.177779	-1.175347	-1.213911	-1.174018	-1.170651
AR(4)	-1.152796	-1.162211	-1.178733	-1.156058	-1.182983	-1.195068
AR(5)	-1.150405	-1.168471	-1.170246	-1.1481	-1.175977	<b>-1.260653</b>

Table 96: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 14-15 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.137477	-1.169997	-1.174862	-1.172214	-1.170499	-1.170562
AR(1)	-1.161769	-1.175094	-1.1724	-1.179038	-1.177295	-1.177287
AR(2)	-1.170943	-1.172413	-1.176919	-1.182759	-1.167994	-1.180342
AR(3)	-1.170339	-1.177626	-1.181287	-1.180538	-1.173343	-1.170849
AR(4)	-1.171741	-1.183239	-1.258596	-1.257684	-1.170943	-1.183265
AR(5)	-1.170082	-1.182395	-1.18559	-1.231843	-1.173565	<b>-1.308965</b>

Table 97: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 15-16 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.193967	-1.229171	-1.226418	-1.224133	-1.22267	-1.219904
AR(1)	-1.22669	-1.226418	-1.243729	-1.227127	-1.224959	-1.222596
AR(2)	-1.226936	-1.242105	-1.240756	-1.299241	-1.240434	-1.236371
AR(3)	-1.224416	-1.237572	-1.25509	-1.235684	-1.237994	-1.233248
AR(4)	-1.221822	-1.22723	-1.24115	-1.237084	-1.23673	-1.236147
AR(5)	-1.219365	-1.228344	-1.296007	-1.237405	-1.245264	<b>-1.344656</b>

Table 98: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 16-17 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.262633	-1.293575	-1.290882	-1.291011	-1.300887	-1.301452
AR(1)	-1.293321	-1.290946	-1.293695	-1.292498	-1.302905	-1.31026
AR(2)	-1.290865	-1.311739	-1.35784	-1.31717	-1.320746	-1.285968
AR(3)	-1.288113	-1.297924	-1.310778	-1.310788	-1.310823	-1.347397
AR(4)	-1.295201	-1.318884	-1.358461	-1.367857	-1.436412	-1.320797
AR(5)	-1.293681	-1.31641	-1.356792	-1.373161	-1.309471	<b>-1.457609</b>

Table 99: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 17-18 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.281558	-1.304526	-1.301815	-1.299567	-1.300858	-1.301764
AR(1)	-1.304232	-1.301855	-1.299418	-1.309153	-1.307076	-1.304358
AR(2)	-1.301846	-1.310337	-1.308028	-1.318591	-1.305774	-1.303166
AR(3)	-1.299083	-1.298393	-1.305791	-1.304939	<b>-1.385202</b>	-1.307052
AR(4)	-1.298119	-1.306873	-1.306809	-1.385188	-1.304198	-1.303996
AR(5)	-1.297211	-1.304118	-1.303327	-1.383228	-1.30632	-1.299527

Table 100: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 18-19 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.097523	-1.127219	-1.126991	-1.124984	-1.13224	-1.131972
AR(1)	-1.122554	-1.146471	-1.151415	-1.12904	-1.147684	-1.145841
AR(2)	-1.1253	-1.151412	-1.144068	-1.153687	-1.154179	-1.151481
AR(3)	-1.122644	-1.128087	-1.156169	-1.199196	<b>-1.204304</b>	-1.202427
AR(4)	-1.122758	-1.147479	-1.155835	-1.204282	-1.201551	-1.199695
AR(5)	-1.120943	-1.144752	-1.154226	-1.202474	-1.156385	-1.159088

Table 101: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 19-20 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.187007	-1.191909	-1.193805	-1.213231	-1.223221	-1.223065
AR(1)	-1.18837	-1.20356	-1.21518	-1.233095	-1.221156	-1.223694
AR(2)	-1.18827	-1.234272	-1.234647	-1.230421	-1.232286	-1.240381
AR(3)	-1.190251	-1.232091	-1.236095	-1.296441	-1.293917	-1.294439
AR(4)	-1.202109	-1.221899	-1.237056	-1.29387	-1.29459	-1.240845
AR(5)	-1.200695	-1.219678	-1.246394	-1.294027	-1.250416	<b>-1.309227</b>

Table 102: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 20-21 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.36004	-1.361279	-1.363951	-1.362414	-1.383819	-1.38151
AR(1)	-1.360628	-1.404361	-1.402163	-1.400164	-1.374961	-1.399916
AR(2)	-1.361698	-1.402097	-1.40243	-1.399592	-1.400109	-1.395758
AR(3)	-1.359215	-1.400096	-1.402791	<b>-1.437751</b>	-1.43562	-1.433408
AR(4)	-1.37635	-1.398078	-1.394445	-1.418682	-1.412799	-1.414331
AR(5)	-1.373676	-1.374886	-1.39957	-1.433238	-1.430477	-1.386383

Table 103: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 21-22 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.672764	-1.688219	-1.6898	-1.693437	-1.694925	-1.692574
AR(1)	-1.687284	-1.718927	-1.720428	-1.718103	-1.70639	-1.702949
AR(2)	-1.688328	-1.720135	-1.718473	-1.721493	-1.616306	-1.71948
AR(3)	-1.6902	-1.687945	-1.709407	-1.734929	-1.740955	-1.729751
AR(4)	-1.697711	-1.701345	-1.705797	-1.732064	-1.710626	-1.731587
AR(5)	-1.695021	-1.700459	-1.723242	-1.712241	-1.707526	<b>-1.748923</b>

Table 104: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 22-23 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.766239	-1.78514	-1.782399	-1.780247	-1.777781	-1.789104
AR(1)	-1.783822	-1.782468	-1.799268	-1.86553	-1.860947	-1.848728
AR(2)	-1.781877	-1.86653	-1.797467	-1.864197	-1.855975	-1.861423
AR(3)	-1.779905	-1.86619	-1.844919	-1.813797	-1.860028	-1.861515
AR(4)	-1.777225	-1.864318	-1.861599	-1.85737	-1.864045	-1.860717
AR(5)	-1.775873	-1.863459	-1.860855	-1.852681	-1.856159	<b>-1.866642</b>

Table 105: AIC values for ARMA parameters in Equation 1(Model-IB) for Hour 23-24 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.422375	-1.423449	-1.420939	-1.420248	-1.422604	-1.424584
AR(1)	-1.423324	-1.458009	-1.419349	-1.453817	-1.45106	-1.448373
AR(2)	-1.420718	-1.419285	-1.455512	-1.432054	-1.449515	-1.442101
AR(3)	-1.419152	-1.453745	-1.450279	-1.465884	-1.444145	-1.412039
AR(4)	-1.419437	-1.450983	-1.447401	<b>-1.476628</b>	-1.472496	-1.457525
AR(5)	-1.420215	-1.448289	-1.403189	-1.450019	-1.457291	-1.437233

Table 106: Results of Model IB –Equation 1 and Equation 3 (2012-14)

Hours	Mean Equation			Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
00-01	-0.0089 (0.1076)	(5,5)		0.0114 (0.1406)	<b>0.002</b> (0.0000)	<b>0.2996</b> (0.0000)	<b>0.6855</b> (0.0000)	<b>-0.0016</b> (0.0003)
		<b>0.3626</b> (0.0001)	<b>-0.4154</b> (0.0001)					
01-02	<b>-0.0148</b> (0.0047)	(4,2)		<b>0.02</b> (0.0049)	<b>0.001</b> (0.0168)	<b>0.2203</b> (0.0000)	<b>0.758</b> (0.0000)	-0.0006 (0.3227)
		<b>-0.1064</b> (0.0053)	<b>-0.2784</b> (0.0271)					
02-03	<b>-0.0175</b> (0.0017)	(1,1)		<b>0.0238</b> (0.0022)	<b>0.0027</b> (0.0000)	<b>0.2846</b> (0.0000)	<b>0.6627</b> (0.0000)	<b>-0.0022</b> (0.0000)
		<b>0.908</b> (0.0000)	<b>-0.9969</b> (0.0000)					
03-04	<b>-0.0219</b> (0.0001)	(4,5)		<b>0.0301</b> (0.0002)	<b>0.0021</b> (0.0000)	<b>0.2471</b> (0.0000)	<b>0.6694</b> (0.0000)	-0.0011 (0.0674)
		<b>0.8683</b> (0.0000)	<b>0.0804</b> (0.0393)					
04-05	<b>-0.0235</b> (0.0000)	(4,4)		<b>0.0325</b> (0.0000)	<b>0.0013</b> (0.0163)	<b>0.2442</b> (0.0000)	<b>0.7082</b> (0.0000)	-0.0004 (0.5717)
		<b>0.5934</b> (0.0000)	<b>-0.7173</b> (0.0000)					
05-06	<b>-0.0275</b> (0.0000)	(3,2)		<b>0.0383</b> (0.0000)	0.001 (0.0778)	<b>0.2084</b> (0.0000)	<b>0.7272</b> (0.0000)	-0.0001 (0.9105)
		<b>0.081</b> (0.0199)	<b>-0.9565</b> (0.0000)					
06-07	<b>-0.0388</b> (0.0000)	(2,2)		<b>0.0531</b> (0.0000)	<b>0.0029</b> (0.0000)	<b>0.2559</b> (0.0000)	<b>0.6715</b> (0.0000)	<b>-0.0024</b> (0.0032)
		0.2123 (0.3864)	-0.2716 (0.3072)					
07-08	<b>-0.0429</b> (0.0000)	(3,3)		<b>0.06</b> (0.0000)	<b>0.0022</b> (0.0001)	<b>0.2175</b> (0.0000)	<b>0.7406</b> (0.0000)	<b>-0.0021</b> (0.0019)
		<b>0.8963</b> (0.0000)	<b>-0.9671</b> (0.0000)					
08-09	<b>-0.0372</b> (0.0000)	(5,5)		<b>0.0506</b> (0.0000)	0.0005 (0.3855)	<b>0.2053</b> (0.0000)	<b>0.7563</b> (0.0000)	0.0005 (0.5534)
		<b>0.6172</b> (0.0000)	<b>-0.7295</b> (0.0000)					
09-10	<b>-0.0403</b> (0.0000)	(5,5)		<b>0.056</b> (0.0000)	<b>0.0038</b> (0.0000)	<b>0.1075</b> (0.0000)	<b>0.8462</b> (0.0000)	<b>-0.0042</b> (0.0000)
		<b>0.635</b> (0.0000)	<b>-0.5668</b> (0.0000)					
10-11	<b>-0.0667</b> (0.0000)	(5,5)		<b>0.0932</b> (0.0000)	<b>0.0095</b> (0.0000)	<b>0.175</b> (0.0000)	<b>0.6426</b> (0.0000)	<b>-0.0088</b> (0.0000)
		<b>0.7513</b> (0.0000)	<b>-0.7494</b> (0.0000)					

Hours	Mean Equation			Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
11-12	<b>-0.0608</b> (0.0000)	(5,5)		<b>0.0842</b> (0.0000)	<b>0.0143</b> (0.0000)	<b>0.1994</b> (0.0000)	<b>0.6225</b> (0.0000)	<b>-0.0144</b> (0.0000)
		<b>0.6802</b> (0.0000)	<b>-0.7088</b> (0.0000)					
12-13	<b>-0.0726</b> (0.0000)	(5,5)		<b>0.101</b> (0.0000)	<b>0.0108</b> (0.0000)	<b>0.2191</b> (0.0000)	<b>0.6275</b> (0.0000)	<b>-0.0105</b> (0.0000)
		<b>0.8843</b> (0.0000)	<b>-0.933</b> (0.0000)					
13-14	<b>-0.0494</b> (0.0000)	(5,5)		<b>0.0688</b> (0.0000)	<b>0.0109</b> (0.0000)	<b>0.1527</b> (0.0000)	<b>0.6856</b> (0.0000)	<b>-0.0108</b> (0.0000)
		<b>0.8554</b> (0.0000)	<b>-0.8629</b> (0.0000)					
14-15	<b>-0.1151</b> (0.0000)	(5,5)		<b>0.1632</b> (0.0000)	<b>0.0087</b> (0.0000)	<b>0.2989</b> (0.0000)	<b>0.6453</b> (0.0000)	<b>-0.0092</b> (0.0000)
		<b>0.8432</b> (0.0000)	<b>-0.9453</b> (0.0000)					
15-16	<b>-0.0444</b> (0.0000)	(5,5)		<b>0.0615</b> (0.0000)	<b>0.0078</b> (0.0000)	<b>0.2</b> (0.0000)	<b>0.6801</b> (0.0000)	<b>-0.0075</b> (0.0000)
		<b>0.9268</b> (0.0000)	<b>-0.939</b> (0.0000)					
16-17	<b>-0.1283</b> (0.0000)	(5,5)		<b>0.1791</b> (0.0000)	<b>0.0032</b> (0.0001)	<b>0.3234</b> (0.0000)	<b>0.6606</b> (0.0000)	<b>-0.0028</b> (0.0032)
		<b>0.9171</b> (0.0000)	<b>-0.9354</b> (0.0000)					
17-18	<b>-0.0709</b> (0.0000)	(3,4)		<b>0.1017</b> (0.0000)	<b>0.0061</b> (0.0000)	<b>0.5297</b> (0.0000)	<b>0.3245</b> (0.0000)	<b>-0.0024</b> (0.0022)
		<b>0.8663</b> (0.0000)	0.0064 (0.8963)					
18-19	<b>-0.0691</b> (0.0000)	(3,4)		<b>0.0969</b> (0.0000)	<b>0.0027</b> (0.0004)	<b>0.27</b> (0.0000)	<b>0.6713</b> (0.0000)	<b>-0.0012</b> (0.1892)
		<b>0.8192</b> (0.0000)	0.0129 (0.7919)					
19-20	<b>-0.0493</b> (0.0000)	(5,5)		<b>0.0703</b> (0.0000)	<b>0.0035</b> (0.0000)	<b>0.5761</b> (0.0000)	<b>0.5335</b> (0.0000)	<b>-0.0032</b> (0.0004)
		<b>0.5981</b> (0.0000)	<b>-0.7738</b> (0.0000)					
20-21	<b>-0.0368</b> (0.0000)	(3,3)		<b>0.0515</b> (0.0000)	<b>0.0046</b> (0.0000)	<b>0.3491</b> (0.0000)	<b>0.5942</b> (0.0000)	<b>-0.0036</b> (0.0000)
		<b>0.7329</b> (0.0000)	<b>-0.9284</b> (0.0000)					
21-22	<b>-0.0179</b> (0.0000)	(5,5)		<b>0.0253</b> (0.0000)	<b>-0.0006</b> (0.0000)	<b>0.4354</b> (0.0000)	<b>0.6619</b> (0.0000)	<b>0.0014</b> (0.0000)
		<b>0.5704</b> (0.0000)	<b>-0.7851</b> (0.0000)					
22-23	<b>-0.0119</b> (0.0004)	(5,5)		<b>0.0159</b> (0.0008)	<b>0.0012</b> (0.0000)	<b>0.8318</b> (0.0000)	<b>0.4595</b> (0.0000)	<b>-0.001</b> (0.0000)
		<b>0.5204</b> (0.0000)	<b>-0.6436</b> (0.0000)					
23-24	<b>-0.027</b>	(4,3)		<b>0.0367</b>	<b>0.0029</b>	<b>0.2919</b>	<b>0.7343</b>	<b>-0.0033</b>

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$
	<b>(0.0000)</b>	-0.0372 (0.3786)	<b>-0.9667</b> <b>(0.0000)</b>	<b>(0.0000)</b>	<b>(0.0000)</b>	<b>(0.0000)</b>	<b>(0.0000)</b>	<b>(0.0000)</b>

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

Model IB is estimated for the second set of period 2012-14 for each hour separately and it is found that the coefficient of dummy variable ( $\beta_2$ ) in the mean equation (Equation 1) is found to be positive and significant for twenty three hours out of the twenty four hours and the coefficient is found to be insignificant for one hour, 00-01. The coefficient of ARCH effect ( $\beta_4$ ) and GARCH effect ( $\beta_5$ ) in variance equation (Equation 3) is found to be significant for all the twenty four hours. The coefficient of the dummy variable ( $\beta_6$ ) which is included in the variance equation (specification of Model IB) is significant for eighteen hours out of the twenty four hours. Six of the hours whose coefficient of dummy variable is not found to be affecting the return volatility, include some of the non peak hours – 01-02, 03-04, 04-05, 05-06, 08-09 and 18-19, when the volume exchanged is low.

In the next subsection, we discuss the Model IIA and Model IIB, here we include the impact of traded volume on the return volatility.

#### 4.1.2 The weekday effect and the effect of trading volume

##### Model IIA

In Model IIA, while there is no change in the mean equation compared to previous model (Model I(A and B)) (Equation 1), in this specification we include a lagged log of volume variable to the volatility equation (Equation 4) to assess the impact of traded volume on return volatility. The AIC values for ARMA parameters in Equation 1 (Model IIA) are reported for hours in Table 107 to Table 130 for 2010-12. Table 131 reports the results of the estimation for the period 1 April 2010 to 31 March 2012.

**Table 107: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 00-01 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.753795	-2.751338	-2.749089	-2.755787	-2.766832	-2.779306
AR(1)	-2.751407	-2.779915	-2.780834	-2.78664	-2.784838	-2.782868
AR(2)	-2.748724	-2.777872	-2.785968	-2.78879	-2.778826	-2.784533
AR(3)	-2.754793	-2.788057	-2.786923	-2.785429	-2.780893	<b>-2.813094</b>
AR(4)	-2.762233	-2.785476	-2.784186	-2.783579	-2.790243	-2.791968
AR(5)	-2.770215	-2.782678	-2.781427	-2.793116	-2.805764	-2.809263

**Table 108: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 01-02 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.86808	-2.866622	-2.865579	-2.865691	-2.882	-2.88786
AR(1)	-2.866668	-2.880958	-2.879091	-2.912226	-2.912202	-2.909384
AR(2)	-2.864633	-2.878423	-2.869169	-2.911652	-2.915033	-2.913161
AR(3)	-2.866488	-2.913212	-2.908614	-2.923535	-2.914114	-2.911314
AR(4)	-2.877925	-2.91089	-2.91735	-2.918064	-2.918454	-2.918431
AR(5)	-2.880451	-2.909775	-2.91472	-2.9122	-2.914776	<b>-2.939608</b>

**Table 109: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 02-03 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.94464	-2.942432	-2.939586	-2.938982	-2.9549	-2.958166
AR(1)	-2.942369	-2.948043	-2.945278	-2.97222	-2.970637	-2.968063
AR(2)	-2.939587	-2.945273	-2.969929	-2.951146	-2.975589	-2.972102
AR(3)	-2.938362	-2.942427	-2.971948	-2.972872	-2.976128	-2.974897
AR(4)	-2.945296	-2.970962	-2.975988	-2.972884	-2.96843	<b>-3.00902</b>
AR(5)	-2.94991	-2.968182	-2.966574	-2.970523	-2.969568	-2.990897

**Table 110: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 03-04 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-3.024725	-3.021905	-3.027398	-3.02448	-3.029383	-3.031163
AR(1)	-3.021913	-3.024398	-3.024662	-3.044246	-3.027369	-3.043811
AR(2)	-3.027051	<b>-3.046492</b>	-3.039181	-3.038522	-3.035666	-3.03648
AR(3)	-3.023115	-3.044357	-3.038689	-3.036215	-3.029059	-3.0324
AR(4)	-3.027251	-3.042755	-3.032376	-3.029158	-3.030565	-3.031587
AR(5)	-3.027756	-3.044423	-3.025304	-3.031509	-3.031354	-3.036982

**Table 111: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 04-05 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.952003	-2.949512	-2.947068	-2.96192	-2.964996	-2.96686
AR(1)	-2.949437	-2.972617	-2.892772	-2.97062	-2.931224	-2.975019
AR(2)	-2.946707	-2.892718	-2.90237	-2.935276	-2.971686	-2.97379
AR(3)	-2.959137	-2.942682	-2.938272	-2.935669	-2.93348	-2.931473
AR(4)	-2.961654	-2.937907	-2.931017	-2.915786	-2.975467	-2.960674
AR(5)	-2.964106	-2.937964	-2.936444	-2.932111	<b>-2.976235</b>	-2.917025

**Table 112: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 05-06 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.934063	-2.932846	-2.930077	-2.936989	-2.977893	-2.982415
AR(1)	-2.933043	-2.931991	-2.930214	-2.975624	-2.982657	-2.980422
AR(2)	-2.930218	-2.93005	-2.945504	-2.98468	-2.982045	-2.983372
AR(3)	-2.931202	-2.976143	-2.982047	-2.985225	-2.983777	-2.984186
AR(4)	-2.963158	-2.982667	-2.982506	-2.980921	<b>-2.989508</b>	-2.986711
AR(5)	-2.968777	-2.985973	-2.981296	-2.978385	-2.986713	-2.98407

**Table 113: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 06-07 (Period 2010-12)**



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-3.137737	-3.136539	-3.137105	-3.140253	-3.157754	-3.159011
AR(1)	-3.136741	-3.133829	-3.135222	-3.171823	-3.170364	-3.167881
AR(2)	-3.135311	-3.131877	-3.169722	-3.170022	-3.171926	-3.168993
AR(3)	-3.140218	-3.171127	-3.168196	-3.169121	-3.169175	-3.167691
AR(4)	-3.15146	-3.168197	-3.170558	-3.169817	-3.16695	-3.164779
AR(5)	-3.148839	-3.147969	-3.168898	<b>-3.177784</b>	-3.166591	-3.171313

Table 114: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 07-08 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.979325	-2.97977	-2.979674	-2.985048	-3.008184	-3.012397
AR(1)	-2.979428	-2.98224	-3.021752	-3.021037	-3.022067	-3.019201
AR(2)	-2.979626	-3.023552	-3.022722	-3.019911	-3.022854	-3.020137
AR(3)	-2.9815	-3.022373	-3.011684	-3.021306	-3.020622	-3.016087
AR(4)	-2.995407	-3.020784	-3.023754	<b>-3.028972</b>	-3.028286	-3.016071
AR(5)	-2.998638	-3.019093	-3.02104	-3.017092	-3.015715	-3.020743

Table 115: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 08-09 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.982052	-2.979872	-2.977293	-2.978843	-2.995822	-3.006576
AR(1)	-2.97985	-2.97919	-3.005177	-3.006616	-3.010004	-3.008141
AR(2)	-2.977332	-3.006494	-3.0082	-2.990219	-3.007782	-3.005469
AR(3)	-2.977877	-3.008138	-3.006296	-3.006665	-3.004497	-3.004745
AR(4)	-2.990938	-3.007592	-3.00627	-3.003405	-3.005366	-3.002577
AR(5)	-2.99972	-3.005696	-3.007357	<b>-3.016126</b>	-3.004414	-2.984387

Table 116: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 09-10 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.831659	-2.83101	-2.828447	-2.828427	-2.839117	-2.842096
AR(1)	-2.830957	-2.852068	-2.849292	-2.847375	-2.843654	-2.840954
AR(2)	-2.828253	-2.849284	-2.845422	-2.855508	-2.849755	-2.838227
AR(3)	-2.826191	-2.84719	-2.832873	-2.840457	-2.843651	-2.854859
AR(4)	-2.833328	-2.841557	-2.846536	<b>-2.925861</b>	-2.857417	-2.850221
AR(5)	-2.83664	-2.846378	-2.849308	-2.860042	-2.843713	-2.857212

Table 117: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 10-11 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.674974	-2.694843	-2.694235	-2.707143	-2.714329	-2.718714
AR(1)	-2.692863	-2.729702	-2.732464	-2.731384	-2.729851	-2.728592
AR(2)	-2.690546	-2.730939	-2.732005	-2.729179	-2.729793	-2.735015
AR(3)	-2.693472	-2.731786	-2.729195	<b>-2.795361</b>	-2.793823	-2.750054
AR(4)	-2.700451	-2.691656	-2.732434	-2.676524	-2.726474	-2.748515
AR(5)	-2.702295	-2.728117	-2.733321	-2.750379	-2.747663	-2.742661

Table 118: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 11-12 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.609868	-2.629001	-2.628534	-2.667189	-2.670113	-2.693569
AR(1)	-2.627809	-2.676325	-2.673781	-2.682629	-2.679989	-2.692497
AR(2)	-2.62502	-2.673898	-2.674928	-2.680203	-2.677877	-2.701524
AR(3)	-2.637316	-2.660358	-2.673336	-2.739106	-2.682263	-2.713379
AR(4)	-2.645897	-2.681673	-2.679781	-2.728391	-2.735154	-2.711291
AR(5)	-2.65707	-2.678904	-2.677932	-2.71384	-2.71106	<b>-2.781889</b>

Table 119: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 12-13 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.55355	-2.569358	-2.573668	-2.593441	-2.598233	-2.628161
AR(1)	-2.572378	-2.580088	-2.581827	-2.627834	-2.626038	-2.629073
AR(2)	-2.578181	-2.579772	-2.609578	-2.628225	-2.622841	-2.628194
AR(3)	-2.585264	-2.630279	-2.627679	-2.695933	-2.693514	-2.666937
AR(4)	-2.596042	-2.627741	-2.627761	-2.693596	-2.617264	-2.663268
AR(5)	-2.599016	-2.625106	-2.633531	-2.664709	-2.662056	<b>-2.730146</b>

Table 120: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 13-14 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.599555	-2.607482	-2.618574	-2.632835	-2.631876	-2.655814
AR(1)	-2.611363	-2.621562	-2.646558	-2.663506	-2.662988	-2.664665
AR(2)	-2.623313	-2.647981	-2.655396	-2.664346	-2.666781	-2.661441
AR(3)	-2.626753	-2.665762	-2.663349	-2.721709	-2.721919	-2.671222
AR(4)	-2.632107	-2.663672	-2.673328	-2.722829	-2.735004	-2.66841
AR(5)	-2.629922	-2.661408	-2.674317	-2.674898	-2.733322	<b>-2.776834</b>

Table 121: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 14-15(Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.475604	-2.503658	-2.502509	-2.539379	-2.551293	-2.568251
AR(1)	-2.502858	-2.500204	-2.483569	-2.582487	-2.580691	-2.567368
AR(2)	-2.500083	-2.502677	-2.554847	-2.580034	-2.585899	-2.615964
AR(3)	-2.50838	-2.578537	-2.575725	-2.648693	-2.612282	-2.62082
AR(4)	-2.529715	-2.575854	-2.571973	-2.646602	-2.554298	-2.635183
AR(5)	-2.536837	-2.583013	-2.58199	-2.587418	-2.640875	<b>-2.701307</b>

Table 122: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 15-16 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.338451	-2.36964	-2.359859	-2.402221	-2.426593	-2.44411
AR(1)	-2.369103	-2.366411	-2.368928	-2.484705	-2.434792	-2.440552
AR(2)	-2.366325	-2.370727	-2.412862	-2.443994	-2.506663	-2.447139
AR(3)	-2.371966	-2.403185	-2.451687	-2.399571	-2.445171	-2.516636
AR(4)	-2.414196	-2.385486	-2.424996	-2.435592	-2.440387	-2.510589
AR(5)	-2.420992	-2.471887	-2.41661	-2.439627	-2.418264	<b>-2.636439</b>

Table 123: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 16-17 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.343649	-2.364333	-2.384189	-2.426702	-2.439938	-2.467998
AR(1)	-2.3683	-2.3722	-2.393251	-2.467434	-2.466859	-2.469494
AR(2)	-2.386572	-2.376233	-2.478486	-2.466483	-2.427577	-2.46683
AR(3)	-2.400595	-2.460134	-2.454461	-2.570938	-2.549402	-2.51397
AR(4)	-2.446794	-2.455227	-2.479157	-2.536873	-2.537244	-2.456151
AR(5)	-2.44763	-2.478553	-2.476123	-2.498133	-2.522023	<b>-2.604617</b>

Table 124: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 17-18 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.315418	-2.335002	-2.345317	-2.357733	-2.366792	-2.483641
AR(1)	-2.349647	-2.338536	-2.345133	-2.507218	-2.504412	-2.508386
AR(2)	-2.347636	-2.34504	-2.564446	-2.504174	-2.548808	-2.500753
AR(3)	-2.34608	-2.342776	-2.476302	-2.416772	-2.504937	-2.566891
AR(4)	-2.357319	-2.477269	-2.50859	-2.452787	-2.593238	-2.516886
AR(5)	-2.360155	-2.50896	-2.559998	-2.471389	-2.506785	<b>-2.66208</b>

Table 125: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 18-19 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.622233	-2.658659	-2.656064	-2.679984	-2.696021	-2.71934
AR(1)	-2.66104	-2.659186	-2.656724	-2.72899	-2.727078	-2.718507
AR(2)	-2.658772	-2.720321	-2.723883	-2.726614	-2.724119	-2.716397
AR(3)	-2.661016	-2.727337	-2.722518	-2.777223	-2.715839	-2.724422
AR(4)	-2.675361	-2.724581	-2.725976	-2.77688	-2.777975	-2.735957
AR(5)	-2.681984	-2.730514	-2.726778	-2.736674	-2.745225	<b>-2.788789</b>

Table 126: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 19-20 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.545817	-2.563285	-2.56093	-2.579564	-2.590928	-2.613238
AR(1)	-2.562686	-2.619461	-2.625664	-2.62589	-2.624049	-2.615361
AR(2)	-2.559942	-2.627043	-2.626035	-2.622224	-2.625312	-2.622547
AR(3)	-2.561275	-2.626307	-2.624959	<b>-2.739444</b>	-2.631029	-2.627645
AR(4)	-2.570851	-2.623537	-2.629135	-2.737265	-2.733283	-2.612012
AR(5)	-2.574788	-2.62503	-2.631681	-2.631274	-2.642051	-2.65775

Table 127: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 20-21 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.654602	-2.665954	-2.66838	-2.680687	-2.696653	-2.707343
AR(1)	-2.66426	-2.717689	-2.68216	-2.711965	-2.710773	-2.710422
AR(2)	-2.665729	-2.715108	-2.698083	-2.720252	-2.721845	-2.708323
AR(3)	-2.667388	-2.713511	-2.720309	-2.709497	-2.72163	-2.713613
AR(4)	-2.674247	-2.71292	-2.722769	-2.721842	-2.717369	-2.731861
AR(5)	-2.683963	-2.706002	-2.719503	-2.704136	-2.713924	<b>-2.77069</b>

Table 128: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 21-22 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.835553	-2.839833	-2.841187	-2.853213	-2.865496	-2.869944
AR(1)	-2.839064	-2.880146	-2.87784	-2.879678	-2.877694	-2.876471
AR(2)	-2.838025	-2.877972	-2.886565	-2.881864	-2.882518	-2.876077
AR(3)	-2.840665	-2.88114	-2.881594	-2.903926	-2.905749	-2.88014
AR(4)	-2.847648	-2.879259	-2.883478	-2.906253	<b>-2.908421</b>	-2.885137
AR(5)	-2.851217	-2.876965	-2.881433	-2.8814	-2.875402	-2.880607

Table 129: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 22-23 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.935598	-2.933886	-2.933107	-2.951699	-2.955814	-2.957472
AR(1)	-2.933756	-2.951299	-2.964316	-2.967119	-2.966637	-2.962432
AR(2)	-2.931638	-2.96495	-2.960877	-2.96503	-2.978169	-2.979652
AR(3)	-2.940997	-2.961858	-2.977388	-2.963295	-2.976186	-2.959828
AR(4)	-2.94119	-2.966075	-2.977984	<b>-2.999492</b>	-2.963942	-2.961141
AR(5)	-2.941666	-2.963502	-2.979224	-2.960312	-2.976054	-2.983917

Table 130: AIC values for ARMA parameters in Equation 1(Model-IIA) for Hour 23-24 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.819215	-2.81709	-2.818792	-2.83355	-2.846761	-2.847372
AR(1)	-2.817013	-2.858983	-2.859633	-2.858576	-2.855903	-2.853433
AR(2)	-2.816557	-2.860007	-2.856781	-2.855838	-2.855572	-2.85341
AR(3)	-2.820883	-2.858534	-2.855757	-2.853215	-2.882339	-2.880941
AR(4)	-2.828834	-2.855757	-2.855965	-2.887143	-2.882531	-2.880838
AR(5)	-2.830189	-2.853644	-2.854261	-2.869739	-2.877091	<b>-2.891007</b>

Table 131: Results of Model IIA -Equation1 and Equation 4 (2010-12)

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
00-01	<b>-0.0117</b> (0.0004)	(3,5)		<b>0.017</b> (0.0001)	-0.0006 (0.2178)	<b>0.4383</b> (0.0000)	<b>0.1749</b> (0.0085)	<b>0.0012</b> (0.0000)
		<b>0.7336</b> (0.0000)	<b>-0.1112</b> (0.014)					
01-02	<b>-0.0162</b> (0.0000)	(5,5)		<b>0.0225</b> (0.0000)	0.0001 (0.9759)	<b>0.4791</b> (0.0000)	<b>-0.0487</b> (0.0129)	<b>0.0011</b> (0.0000)
		<b>0.7016</b> (0.0000)	<b>-0.7196</b> (0.0000)					
02-03	<b>-0.0147</b> (0.0000)	(4,5)		<b>0.0208</b> (0.0000)	0.0008 (0.1307)	<b>0.3729</b> (0.0000)	<b>-0.0948</b> (0.0214)	<b>0.0008</b> (0.0017)
		<b>0.7735</b> (0.0000)	<b>0.0109</b> (0.0000)					
03-04	<b>-0.0153</b> (0.0000)	(2,1)		<b>0.0216</b> (0.0000)	<b>0.0022</b> (0.002)	<b>0.335</b> (0.0000)	-0.0393 (0.6437)	-0.0001 (0.9972)
		-0.0574 (0.193)	<b>-0.9963</b> (0.0000)					
04-05	<b>-0.0153</b> (0.0000)	(5,4)		<b>0.0211</b> (0.0000)	<b>0.0039</b> (0.0000)	<b>0.2212</b> (0.0000)	-0.0061 (0.9661)	<b>-0.0008</b> (0.031)
		<b>-0.1119</b> (0.0107)	-0.3247 (0.2733)					
05-06	<b>-0.016</b>	(4,4)		<b>0.0217</b>	<b>0.0012</b>	<b>0.2588</b>	<b>0.5726</b>	-0.0003

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
	(0.0000)	0.5029 (0.0000)	-0.7281 (0.0000)	(0.0000)	(0.0006)	(0.0000)	(0.0000)	(0.0544)
06-07	<b>-0.0191</b> (0.0000)	(5,3)		<b>0.0263</b> (0.0000)	<b>0.0012</b> (0.0000)	<b>0.2871</b> (0.0000)	<b>0.4777</b> (0.0000)	<b>-0.0003</b> (0.0206)
		<b>-0.1088</b> (0.0166)	<b>-0.8192</b> (0.0000)					
07-08	<b>-0.02</b> (0.0000)	(4,3)		<b>0.0277</b> (0.0001)	0.0002 (0.0827)	<b>0.0274</b> (0.0073)	<b>0.8886</b> (0.0000)	1.00E-04 (0.0547)
		<b>-0.1499</b> (0.0005)	<b>-0.8861</b> (0.0000)					
08-09	<b>-0.0234</b> (0.0000)	(5,3)		<b>0.0329</b> (0.0000)	<b>0.0013</b> (0.0297)	<b>0.3837</b> (0.0000)	0.098 (0.2703)	0.0003 (0.3982)
		-0.0753 (0.0811)	<b>-0.8846</b> (0.0000)					
09-10	<b>-0.0304</b> (0.0000)	(4,3)		<b>0.0421</b> (0.0000)	<b>0.0018</b> (0.0029)	<b>0.515</b> (0.0000)	0.0677 (0.1351)	-1.72E-05 (0.948)
		-0.0454 (0.285)	<b>-0.9512</b> (0.0000)					
10-11	<b>-0.0302</b> (0.0000)	(3,3)		<b>0.0423</b> (0.0000)	0.0014 (0.0706)	<b>0.5908</b> (0.0000)	<b>0.1071</b> (0.0022)	0.0001 (0.7477)
		<b>0.8399</b> (0.0000)	<b>-0.8932</b> (0.0000)					
11-12	<b>-0.0508</b> (0.0000)	(5,5)		<b>0.0707</b> (0.0000)	0.0007 (0.3821)	<b>0.3225</b> (0.0000)	<b>0.3598</b> (0.0000)	0.0002 (0.4722)
		<b>0.8232</b> (0.0000)	<b>-0.9369</b> (0.0000)					
12-13	<b>-0.0425</b> (0.0000)	(5,5)		<b>0.0598</b> (0.0000)	0.0003 (0.5862)	<b>0.589</b> (0.0000)	<b>0.3242</b> (0.0000)	0.0002 (0.3171)
		<b>0.8381</b> (0.0000)	<b>-0.9338</b> (0.0000)					
13-14	<b>-0.0537</b> (0.0000)	(5,5)		<b>0.0752</b> (0.0000)	0.001 (0.2733)	<b>0.6277</b> (0.0000)	<b>0.1435</b> (0.0153)	0.0002 (0.5861)
		<b>0.8543</b> (0.0000)	<b>-0.8683</b> (0.0000)					
14-15	<b>-0.0606</b> (0.0000)	(5,5)		<b>0.0839</b> (0.0000)	0.0008 (0.2424)	<b>0.3689</b> (0.0000)	<b>0.4829</b> (0.0000)	2.44E-05 (0.9309)
		<b>0.8179</b> (0.0000)	<b>-0.8647</b> (0.0000)					
15-16	<b>-0.0621</b> (0.0000)	(5,5)		<b>0.0871</b> (0.0000)	<b>0.0037</b> (0.0006)	<b>0.6806</b> (0.0000)	-0.0088 (0.7746)	-0.0005 (0.1918)
		<b>0.8715</b> (0.0000)	<b>-0.7655</b> (0.0000)					
16-17	<b>-0.0644</b> (0.0000)	(5,5)		<b>0.0892</b> (0.0000)	0.0001 (0.8686)	<b>0.6404</b> (0.0000)	-0.0273 (0.3988)	<b>0.001</b> (0.0000)
		<b>0.7913</b> (0.0000)	<b>-0.7501</b> (0.0000)					
17-18	<b>-0.0475</b> (0.0000)	(5,5)		<b>-0.8039</b> (0.0000)	0.0002 (0.6964)	<b>0.4484</b> (0.0000)	<b>0.4497</b> (0.0000)	0.0002 (0.3743)
		<b>0.0664</b> (0.0000)	<b>0.8064</b> (0.0000)					
18-19	<b>-0.0337</b>	(5,5)		<b>0.001</b>	0.4144	<b>0.4935</b>		

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
	(0.0000)	<b>0.6774</b> (0.0000)	<b>-0.8267</b> (0.0000)	<b>0.0466</b> (0.0000)	(0.0701)	<b>(0.0000)</b>	<b>(0.0000)</b>	-0.0001 (0.4369)
19-20	<b>-0.0305</b> (0.0000)	(3,3)		<b>0.0427</b> (0.0000)	<b>0.0015</b> (0.042)	<b>0.4698</b> (0.0000)	<b>0.2751</b> (0.0000)	-0.0001 (0.7201)
		<b>0.8806</b> (0.0000)	<b>-0.9971</b> (0.0000)					
20-21	<b>-0.0534</b> (0.0000)	(5,5)		<b>0.0741</b> (0.0000)	<b>0.0009</b> (0.0178)	<b>0.1671</b> (0.0001)	<b>0.6162</b> (0.0000)	-6.92E-05 (0.5931)
		<b>0.7353</b> (0.0000)	<b>-0.9205</b> (0.0000)					
21-22	<b>-0.0247</b> (0.0000)	(4,4)		<b>0.0342</b> (0.0000)	0.0004 (0.1175)	<b>0.1324</b> (0.0001)	<b>0.6657</b> (0.0000)	0.0001 (0.2267)
		<b>-0.6631</b> (0.0000)	<b>0.6518</b> (0.0000)					
22-23	<b>-0.0228</b> (0.0000)	(4,3)		<b>0.0313</b> (0.0000)	6.77E-05 (0.7592)	<b>0.1541</b> (0.0000)	<b>0.6286</b> (0.0000)	<b>0.0002</b> (0.0069)
		<b>-0.1118</b> (0.0000)	<b>-0.8703</b> (0.0000)					
23-24	<b>-0.015</b> (0.0004)	(5,5)		<b>0.0213</b> (0.0003)	<b>0.0012</b> (0.0004)	<b>0.2263</b> (0.0000)	<b>0.5551</b> (0.0000)	-0.0002 (0.1469)
		<b>0.3109</b> (0.0000)	<b>-0.2362</b> (0.0000)					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

Model IIA is estimated for the first set of period 2010-12 for each hour separately and it is found that the coefficients of dummy variable ( $\beta_2$ ) are significant for twenty one hours out of the twenty four hours. The cases of insignificant dummy effect on return include three hours namely - 18-19, 21-22 and 22-23. In the variance equation, ARCH effects ( $\beta_4$ ) remain significant for all the hours while GARCH effects ( $\beta_5$ ) are significant for eighteen hours out of twenty four hours. GARCH effect is insignificant in case of 03-04, 04-05, 08-09, 09-10, 15-16 and 16-17 hours.

While the coefficient of volume ( $\beta_7$ ) (lagged log of volume) is significant only for seven hours out of the twenty four hours (00-01, 01-02, 02-03, 04-05, 06-07, 16-17, 22-23). For the insignificant, volume effects in case of seventeen hours out of twenty four hours, it can be concluded that information does not flow at the same time of auction. Participants at the power exchange purchase or sell electricity contracts depending on their requirement.

The AIC values for ARMA parameters in mean equation (Equation 1 of Model IIA) are reported for hours in Table 132 to Table 155 for 2012-14. Table 156 reports the results of the estimation for the period 2012-14.

**Table 132: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 00-01 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.576091	-1.573686	-1.576184	-1.577604	-1.58215	-1.580383
AR(1)	-1.573552	-1.571881	-1.579307	-1.577001	-1.627419	-1.62506
AR(2)	-1.57504	-1.579204	-1.62523	-1.5841	-1.624304	-1.587302
AR(3)	-1.577364	-1.577537	-1.599456	-1.589374	-1.624345	-1.621996
AR(4)	-1.583419	-1.627302	-1.628671	-1.621593	-1.623259	-1.615367
AR(5)	-1.580666	-1.626494	-1.582427	-1.621731	-1.622226	<b>-1.638131</b>

**Table 133: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 01-02 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.619962	-1.617441	-1.616003	-1.61453	-1.618472	-1.616442
AR(1)	-1.617443	-1.655031	-1.615137	-1.613424	-1.653196	-1.651741
AR(2)	-1.615822	-1.615142	-1.618017	-1.615276	-1.650693	-1.649383
AR(3)	-1.615057	-1.614338	-1.615296	-1.657217	-1.648556	-1.654968
AR(4)	-1.620243	-1.654366	<b>-1.669152</b>	-1.623532	-1.668981	-1.666237
AR(5)	-1.617955	-1.645221	-1.651311	-1.654977	-1.666155	-1.637357

**Table 134: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 02-03 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.681222	-1.678812	-1.680738	-1.678109	-1.681969	-1.679664
AR(1)	-1.678609	<b>-1.719052</b>	-1.716736	-1.678635	-1.714149	-1.712272
AR(2)	-1.680118	-1.716701	-1.71832	-1.715969	-1.712397	-1.710537
AR(3)	-1.677512	-1.714312	-1.715948	-1.709914	-1.709263	-1.71851
AR(4)	-1.679846	-1.713751	-1.712038	-1.709404	-1.718415	-1.706425
AR(5)	-1.677204	-1.712839	-1.71032	-1.705699	-1.707748	-1.701378

**Table 135: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 03-04 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.62576	-1.62667	-1.6248	-1.622619	-1.622258	-1.619725
AR(1)	-1.625822	-1.654625	-1.652369	-1.623586	-1.646933	-1.624309
AR(2)	-1.624004	-1.652394	-1.649581	-1.647883	-1.649664	-1.646914
AR(3)	-1.621923	-1.623485	-1.652345	-1.642137	-1.640919	-1.648483
AR(4)	-1.620632	-1.646887	-1.649698	-1.646919	<b>-1.671466</b>	-1.651831
AR(5)	-1.61824	-1.644188	-1.646964	-1.639053	-1.652108	-1.659883

**Table 136: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 04-05 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-1.559187	-1.557481	-1.565992	-1.563563	-1.563595	-1.560828
AR(1)	-1.556873	-1.592416	-1.589678	-1.591156	-1.591751	-1.588985
AR(2)	-1.565312	-1.589668	-1.597507	-1.596281	-1.593926	-1.587908
AR(3)	-1.562609	-1.591596	-1.596082	-1.592815	-1.570094	-1.592905
AR(4)	-1.560688	-1.590414	-1.594065	-1.59286	-1.607126	<b>-1.609782</b>
AR(5)	-1.557983	-1.58765	-1.534008	-1.588659	-1.608292	-1.607017

**Table 137: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 05-06 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.630262	-1.630696	-1.62822	-1.627189	-1.629098	-1.628137
AR(1)	-1.630519	-1.680526	-1.677826	-1.628117	-1.6805	-1.677736
AR(2)	-1.628346	-1.677832	-1.678829	-1.624468	-1.677577	-1.687898
AR(3)	-1.627376	-1.62805	-1.67669	-1.634898	-1.675284	-1.67437
AR(4)	-1.628509	-1.680375	-1.687147	-1.67566	-1.672974	-1.672829
AR(5)	-1.626027	-1.677834	<b>-1.699638</b>	-1.635583	-1.673066	-1.683748

Table 138: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 06-07 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.694588	-1.692046	-1.690975	-1.689544	-1.68678	-1.688
AR(1)	-1.692024	-1.714285	-1.713013	-1.709804	-1.707113	-1.705839
AR(2)	-1.691046	-1.712558	-1.737831	-1.708842	-1.704372	-1.703105
AR(3)	-1.68902	<b>-1.740412</b>	-1.70896	-1.71291	-1.710146	-1.719546
AR(4)	-1.68626	-1.707177	-1.705604	-1.710021	-1.722677	-1.702434
AR(5)	-1.687217	-1.705781	-1.700276	-1.719513	-1.707846	-1.719491

Table 139: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 07-08 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.770503	-1.768228	-1.767445	-1.771862	-1.769703	-1.766938
AR(1)	-1.768033	-1.766575	-1.766269	-1.769099	-1.767269	-1.790102
AR(2)	-1.76706	-1.766937	-1.770881	-1.781438	-1.766437	-1.780438
AR(3)	-1.77157	-1.769149	-1.781554	-1.767045	-1.784444	-1.777716
AR(4)	-1.76964	-1.774821	-1.766895	-1.797786	<b>-1.802828</b>	-1.779319
AR(5)	-1.766897	-1.765671	-1.777685	-1.775379	-1.787757	-1.797464

Table 140: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 08-09 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.624127	-1.623109	-1.621323	-1.620474	-1.619763	-1.619546
AR(1)	-1.623083	-1.620227	-1.618579	-1.619376	-1.61774	-1.617134
AR(2)	-1.62127	-1.618588	-1.62402	-1.624741	-1.621128	-1.62365
AR(3)	-1.621148	-1.619015	-1.629902	-1.620734	<b>-1.647416</b>	-1.622092
AR(4)	-1.619339	-1.618732	-1.614851	-1.620182	-1.633107	-1.615126
AR(5)	-1.616862	-1.614277	-1.621351	-1.62872	-1.626422	-1.641094

Table 141: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 09-10 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.388186	-1.384501	-1.382837	-1.380264	-1.377549	-1.37649
AR(1)	-1.385269	-1.383516	-1.381824	-1.377649	-1.382783	-1.388389
AR(2)	-1.383034	-1.383442	-1.431378	-1.378842	-1.374696	-1.426118
AR(3)	-1.380349	-1.377809	-1.392013	-1.456007	-1.383378	-1.451428
AR(4)	-1.378453	-1.415328	-1.373503	-1.453917	-1.451859	-1.446427
AR(5)	-1.409865	-1.399985	-1.44388	-1.451245	-1.449233	<b>-1.460866</b>

Table 142: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 10-11 (Period 2012-14)



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.261062	-1.269053	-1.266323	-1.265708	-1.263208	-1.260587
AR(1)	-1.269161	-1.266396	-1.275692	-1.275333	-1.2726	-1.273057
AR(2)	-1.266395	-1.276205	-1.321798	-1.297876	-1.27973	-1.27756
AR(3)	-1.26448	-1.274938	-1.274309	-1.288402	-1.330908	-1.314016
AR(4)	-1.263257	-1.281034	-1.284586	-1.330772	-1.32927	-1.326849
AR(5)	-1.261681	-1.280653	-1.28396	-1.312875	-1.326763	<b>-1.345578</b>

Table 143: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 11-12 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.036265	-1.069317	-1.066703	-1.064411	-1.061659	-1.059038
AR(1)	-1.068374	-1.0667	-1.065837	-1.072666	-1.070559	-1.068086
AR(2)	-1.066398	-1.068223	-1.072818	-1.057359	-1.069042	-1.054891
AR(3)	-1.064041	-1.072821	-1.063225	-1.13694	-1.133711	-1.135504
AR(4)	-1.061773	-1.070126	-1.072049	-1.132569	-1.080482	-1.055924
AR(5)	-1.059177	-1.070503	-1.073956	-1.138228	<b>-1.140395</b>	-1.133761

Table 144: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 12-13 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.046647	-1.080557	-1.077836	-1.078915	-1.077438	-1.075604
AR(1)	-1.079522	-1.077833	-1.078534	-1.095737	-1.098837	-1.084672
AR(2)	-1.077142	-1.081856	-1.076413	-1.079006	-1.091206	-1.098393
AR(3)	-1.07654	-1.096051	-1.099951	-1.178326	<b>-1.178728</b>	-1.078478
AR(4)	-1.07769	-1.093807	-1.099622	-1.178015	-1.116869	-1.085458
AR(5)	-1.075442	-1.094956	-1.111175	-1.098294	-1.089832	-1.172932

Table 145: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 13-14 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.0302	-1.057468	-1.054702	-1.052448	-1.050654	-1.047908
AR(1)	-1.055366	-1.054711	-1.05742	-1.072715	-1.076928	-1.029691
AR(2)	-1.053972	-1.061084	-1.071051	-1.089777	-1.071563	-1.056704
AR(3)	-1.051436	-1.088023	-1.052567	-1.149223	-1.089994	-1.075482
AR(4)	-1.05083	-1.068581	-1.07591	-1.155694	-1.118312	-1.083823
AR(5)	-1.048911	-1.053742	-1.100594	-1.133771	-1.044112	<b>-1.167357</b>

Table 146: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 14-15(Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.039432	-1.065817	-1.064581	-1.062267	-1.061611	-1.06385
AR(1)	-1.060784	-1.063802	-1.071378	-1.069272	-1.071507	-1.089175
AR(2)	-1.06239	-1.074867	-1.061966	-1.07963	-1.06423	-1.084035
AR(3)	-1.061986	-1.068488	-1.0776	-1.040733	-1.213355	<b>-1.218458</b>
AR(4)	-1.061473	-1.086846	-1.075871	-1.118614	-1.069164	-1.076231
AR(5)	-1.066012	-1.100579	-1.082922	-1.117302	-1.101773	-1.207165

Table 147: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 15-16 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.144457	-1.166722	-1.164107	-1.161598	-1.159197	-1.156624
AR(1)	-1.164596	-1.164273	-1.1753	-1.175348	-1.173574	-1.173266
AR(2)	-1.163334	-1.177971	-1.270992	-1.182231	-1.181716	-1.175696
AR(3)	-1.16087	-1.175212	-1.185141	-1.281632	-1.279383	-1.276617
AR(4)	-1.158638	-1.178796	-1.183767	-1.279392	-1.182666	-1.15242
AR(5)	-1.157147	-1.180133	-1.182899	-1.276626	-1.158421	<b>-1.289703</b>

Table 148: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 16-17 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.210877	-1.244441	-1.241905	-1.245891	-1.258261	-1.25807
AR(1)	-1.245043	-1.242343	-1.262448	-1.236972	-1.259436	-1.268284
AR(2)	-1.242322	-1.264729	-1.252043	-1.260211	-1.265783	-1.267867
AR(3)	-1.239925	-1.262866	-1.266846	-1.326986	-1.333006	-1.342486
AR(4)	-1.25257	-1.253714	-1.257714	-1.350807	-1.427531	<b>-1.438924</b>
AR(5)	-1.250855	-1.265269	-1.282618	-1.358737	-1.350731	-1.375394

Table 149: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 17-18 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.262243	-1.284373	-1.28293	-1.280908	-1.280511	-1.280436
AR(1)	-1.286029	-1.283299	-1.280645	-1.288159	-1.281496	-1.282831
AR(2)	-1.283284	-1.28797	-1.286492	-1.285622	-1.286314	-1.284795
AR(3)	-1.280518	-1.28739	-1.285167	<b>-1.385715</b>	-1.383012	-1.380944
AR(4)	-1.279848	-1.285566	-1.291005	-1.383079	-1.381226	-1.293356
AR(5)	-1.277233	-1.282974	-1.290265	-1.372717	-1.28875	-1.292207

Table 150: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 18-19 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.078796	-1.116686	-1.117537	-1.115908	-1.124418	-1.122289
AR(1)	-1.109865	-1.131121	-1.140322	-1.137631	-1.126204	-1.124792
AR(2)	-1.114756	-1.139567	-1.100829	-1.145928	-1.145315	-1.13411
AR(3)	-1.11238	-1.137899	-1.149162	<b>-1.206516</b>	-1.204034	-1.202637
AR(4)	-1.113943	-1.127091	-1.148048	-1.203962	-1.202489	-1.199953
AR(5)	-1.111236	-1.105646	-1.148985	-1.202707	-1.112686	-1.200278

Table 151: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 19-20 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.175905	-1.178073	-1.178705	-1.194925	-1.20194	-1.195861
AR(1)	-1.175197	-1.206818	-1.211651	-1.205049	-1.209879	-1.208796
AR(2)	-1.174046	-1.210917	-1.211791	-1.192334	-1.215075	-1.222653
AR(3)	-1.176779	-1.208594	-1.217863	-1.225469	-1.278622	-1.281157
AR(4)	-1.196635	-1.218738	-1.221414	-1.281558	-1.277889	-1.233688
AR(5)	-1.193896	-1.216486	-1.233098	-1.280904	-1.263532	<b>-1.293722</b>

Table 152: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 20-21 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.352272	-1.355325	-1.358483	-1.355502	-1.371106	-1.37017
AR(1)	-1.353929	-1.39759	-1.364016	-1.392929	-1.391479	-1.392584
AR(2)	-1.354977	-1.395002	-1.397831	-1.375845	-1.363229	-1.39517
AR(3)	-1.352319	-1.392818	-1.397834	-1.430985	-1.395724	-1.424341
AR(4)	-1.367848	-1.370613	-1.396472	-1.429113	-1.427533	-1.404783
AR(5)	-1.367298	-1.368103	-1.37351	-1.415282	-1.421515	<b>-1.431521</b>

Table 153: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 21-22 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.683754	-1.699967	-1.701348	-1.704029	-1.707692	-1.705161
AR(1)	-1.700337	-1.697947	-1.731761	-1.707488	-1.714393	-1.719048
AR(2)	-1.701281	-1.698612	-1.729869	-1.726782	-1.730408	-1.73094
AR(3)	-1.702055	-1.699345	-1.733749	-1.744135	<b>-1.752198</b>	-1.740198
AR(4)	-1.710713	-1.71188	-1.71827	-1.743112	-1.675876	-1.737091
AR(5)	-1.708436	-1.726158	-1.726905	-1.740039	-1.719877	-1.749336

Table 154: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 22-23 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.785842	-1.7967	-1.794744	-1.793797	-1.791572	-1.789796
AR(1)	-1.797758	-1.795541	-1.793862	-1.852184	-1.852402	-1.851829
AR(2)	-1.7953	-1.798117	-1.79733	-1.80338	-1.843502	-1.849802
AR(3)	-1.793283	-1.854215	-1.843596	-1.81012	-1.850658	-1.832632
AR(4)	-1.7912	-1.852259	-1.841556	-1.852816	-1.821224	-1.858352
AR(5)	-1.789379	-1.851266	-1.850378	-1.840015	-1.855015	<b>-1.858939</b>

Table 155: AIC values for ARMA parameters in Equation 1 (Model-IIA) for Hour 23-24 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.430055	-1.432414	-1.430385	-1.430726	-1.435105	-1.439159
AR(1)	-1.432138	-1.471029	-1.428802	-1.466865	-1.427879	-1.461975
AR(2)	-1.429838	-1.422524	-1.467463	-1.441065	-1.461874	-1.461363
AR(3)	-1.428771	-1.46725	-1.439816	-1.446373	-1.459813	-1.44595
AR(4)	-1.430042	-1.46351	-1.462797	-1.460021	-1.407355	-1.470241
AR(5)	-1.431446	-1.46186	-1.459481	-1.469279	-1.452715	<b>-1.478772</b>

Table 156: Results of Model-IIA Equation 1 and Equation 4 (2012-14)

Hours	Mean Equation			Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
00-01	-0.0094 (0.0663)	(5,5)		0.0122 (0.0912)	-0.002 (0.1167)	<b>0.285</b> (0.0000)	<b>0.7089</b> (0.0000)	<b>0.0009</b> (0.0362)
		<b>0.4476</b> (0.0006)	<b>-0.5161</b> (0.0001)					
01-02	<b>-0.0132</b> (0.0027)	(4,2)		<b>0.0188</b> (0.0029)	-0.0014 (0.1067)	<b>0.2246</b> (0.0000)	<b>0.765</b> (0.0000)	<b>0.0006</b> (0.0288)
		<b>-0.092</b> (0.04)	<b>-0.5455</b> (0.0473)					
02-03	<b>-0.0175</b>	(1,1)		<b>0.0238</b>	<b>0.0101</b>	<b>0.2623</b>	<b>0.621</b>	<b>-0.0029</b>

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
	(0.0005)	0.9217 (0.0000)	-0.9961 (0.0000)	(0.0007)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
03-04	<b>-0.0202</b> (0.0002)	(4,4)		<b>0.0279</b> (0.0002)	<b>0.0066</b> (0.0005)	<b>0.23</b> (0.0000)	<b>0.653</b> (0.0000)	<b>-0.0017</b> (0.0027)
		<b>0.8245</b> (0.0000)	<b>-0.944</b> (0.0000)					
04-05	<b>-0.0229</b> (0.0001)	(4,5)		<b>0.0316</b> (0.0001)	<b>0.0091</b> (0.0001)	<b>0.2569</b> (0.0000)	<b>0.6196</b> (0.0000)	<b>-0.0026</b> (0.0004)
		<b>0.6891</b> (0.0000)	0.0605 (0.2637)					
05-06	<b>-0.0284</b> (0.0000)	(5,2)		<b>0.0388</b> (0.0000)	<b>0.0032</b> (0.0473)	<b>0.208</b> (0.0000)	<b>0.7128</b> (0.0000)	-0.0007 (0.1397)
		<b>-0.0167</b> (0.0065)	<b>-0.9981</b> (0.0000)					
06-07	<b>-0.0398</b> (0.0000)	(3,1)		<b>0.0553</b> (0.0000)	<b>0.0041</b> (0.0019)	<b>0.2499</b> (0.0000)	<b>0.6429</b> (0.0000)	<b>-0.0009</b> (0.0319)
		-0.0464 (0.1536)	<b>-1.0146</b> (0.0000)					
07-08	<b>-0.0446</b> (0.0000)	(4,4)		<b>0.0627</b> (0.0000)	<b>0.0015</b> (0.0916)	<b>0.2339</b> (0.0000)	<b>0.7182</b> (0.0000)	-0.0002 (0.3053)
		<b>0.6566</b> (0.0000)	<b>-0.8035</b> (0.0000)					
08-09	<b>-0.0396</b> (0.0000)	(3,4)		<b>0.0546</b> (0.0000)	-0.0008 (0.126)	<b>0.1822</b> (0.0000)	<b>0.7822</b> (0.0000)	<b>0.0005</b> (0.004)
		<b>0.7863</b> (0.0000)	<b>-0.1206</b> (0.0077)					
09-10	<b>-0.0427</b> (0.0000)	(5,5)		<b>0.0581</b> (0.0000)	-0.0006 (0.5126)	<b>0.1286</b> (0.0000)	<b>0.8451</b> (0.0000)	0.0004 (0.1571)
		<b>0.6509</b> (0.0000)	<b>-0.6082</b> (0.0000)					
10-11	<b>-0.0731</b> (0.0000)	(5,5)		<b>0.1032</b> (0.0000)	<b>0.023</b> (0.002)	<b>0.1996</b> (0.0000)	<b>0.4031</b> (0.0000)	<b>-0.0054</b> (0.0122)
		<b>0.7937</b> (0.0000)	<b>-0.8616</b> (0.0000)					
11-12	<b>-0.1383</b> (0.0000)	(5,4)		<b>0.192</b> (0.0000)	0.002 (0.6046)	<b>0.3377</b> (0.0000)	<b>0.5873</b> (0.0000)	0.0003 (0.786)
		<b>0.2559</b> (0.0000)	<b>-0.8187</b> (0.0001)					
12-13	<b>-0.0731</b> (0.0000)	(3,4)		<b>0.1021</b> (0.0000)	-0.0005 (0.831)	<b>0.1648</b> (0.0000)	<b>0.7941</b> (0.0000)	0.0005 (0.4682)
		<b>0.8616</b> (0.0000)	0.0948 (0.1107)					
13-14	<b>-0.0564</b> (0.0000)	(5,5)		<b>0.0815</b> (0.0000)	0.0027 (0.4565)	<b>0.3705</b> (0.0000)	<b>0.6658</b> (0.0000)	-0.0004 (0.6989)
		<b>0.8467</b> (0.0000)	<b>-0.9638</b> (0.0000)					
14-15	<b>-0.0581</b> (0.0000)	(3,5)		<b>0.0851</b> (0.0000)	<b>0.0085</b> (0.0189)	<b>0.3994</b> (0.0000)	<b>0.6004</b> (0.0000)	<b>-0.0021</b> (0.0566)
		<b>0.9085</b> (0.0000)	<b>0.1095</b> (0.04)					
15-16	<b>-0.071</b> (0.0000)	(5,5)		<b>0.0989</b> (0.0000)	<b>0.0153</b> (0.0163)	<b>0.8311</b> (0.0000)	0.0505 (0.0991)	-0.0025 (0.2187)
		<b>0.8463</b> (0.0000)	<b>-0.9171</b> (0.0000)					

Hours	Mean Equation			Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_7$
16-17	<b>-0.1292</b> (0.0000)	(4,5)		<b>0.1803</b> (0.0000)	0.0014 (0.5222)	<b>0.3804</b> (0.0000)	<b>0.6542</b> (0.0000)	-0.0001 (0.8116)
		<b>-0.9922</b> (0.0000)	<b>-0.1526</b> (0.0013)					
17-18	<b>-0.0719</b> (0.0000)	(3,3)		<b>0.1028</b> (0.0000)	<b>0.0179</b> (0.0012)	<b>0.57</b> (0.0000)	<b>0.2938</b> (0.0000)	<b>-0.0044</b> (0.0123)
		<b>0.8824</b> (0.0000)	<b>-0.9141</b> (0.0000)					
18-19	<b>-0.0683</b> (0.0000)	(3,3)		<b>0.0956</b> (0.0000)	-0.0004 (0.8773)	<b>0.2767</b> (0.0000)	<b>0.6844</b> (0.0000)	0.0006 (0.4723)
		<b>0.8136</b> (0.0000)	<b>-0.9077</b> (0.0000)					
19-20	<b>-0.0491</b> (0.0000)	(5,5)		<b>0.0705</b> (0.0000)	0.0003 (0.9284)	<b>0.6</b> (0.0000)	<b>0.5379</b> (0.0000)	0.0002 (0.854)
		<b>0.5964</b> (0.0000)	<b>-0.7808</b> (0.0000)					
20-21	<b>-0.0299</b> (0.0000)	(5,5)		<b>0.0415</b> (0.0000)	<b>-0.0073</b> (0.0000)	<b>0.4294</b> (0.0000)	<b>0.6428</b> (0.0000)	<b>0.0027</b> (0.0000)
		<b>0.5794</b> (0.0000)	<b>-0.8272</b> (0.0000)					
21-22	<b>-0.0169</b> (0.0000)	(3,4)		<b>0.0235</b> (0.0000)	<b>-0.0037</b> (0.0000)	<b>0.4127</b> (0.0000)	<b>0.6519</b> (0.0000)	<b>0.0014</b> (0.0000)
		<b>0.7338</b> (0.0000)	0.0644 (0.2023)					
22-23	<b>-0.0109</b> (0.0003)	(5,5)		<b>0.0146</b> (0.0006)	-0.0012 (0.2324)	<b>0.8439</b> (0.0000)	<b>0.4861</b> (0.0000)	0.0004 (0.1407)
		<b>0.5147</b> (0.0000)	<b>-0.6265</b> (0.0000)					
23-24	<b>-0.0217</b> (0.0000)	(5,5)		<b>0.0296</b> (0.0000)	<b>-0.0035</b> (0.0000)	<b>0.2419</b> (0.0000)	<b>0.7703</b> (0.0000)	<b>0.0013</b> (0.0000)
		<b>0.7104</b> (0.0000)	<b>-0.8357</b> (0.0000)					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

From Table 156, it is observed that the coefficients of dummy variable ( $\beta_2$ ) are significant for all hours except hour 00-01 (a non-peak hour). In the variance equation (Equation.4), ARCH effects ( $\beta_4$ ) remain significant for all the hours while GARCH effects ( $\beta_5$ ) are significant for all hours except hour 15-16. While the coefficient of volume ( $\beta_7$ ) (lagged log of volume) is significant for thirteen hours out of the twenty four hours except eleven hours for which volume effect is insignificant (05-06, 07-08, 09-10, 11-12,12-13, 13-14,15-16, 16-17, 18-19, 19-20 and 22-23).

### Model IIB

In Model-IIB, while the mean equation is same as previous models (Equation 1), we include a lagged log of volume variable ( $\beta_7$ ) and a dummy variable ( $\beta_6$ ) for weekday effect to the volatility equation (Equation 5) to assess the impact of volume and weekday effect on return volatility of

the twenty four hours respectively. The AIC values for ARMA parameters in mean equation (Equation 1 of Model IIB) are reported for hours in Table 157 to Table 180 for period 2010-12.

**Table 157: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 00-01 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.754982	-2.752725	-2.750373	-2.756975	-2.766819	-2.778674
AR(1)	-2.752827	-2.754363	-2.754081	-2.785238	-2.783301	-2.78132
AR(2)	-2.750073	-2.753283	-2.785035	-2.78802	-2.785924	-2.783991
AR(3)	-2.756779	-2.786632	-2.78597	-2.79458	-2.792559	-2.812493
AR(4)	-2.76338	-2.784045	-2.783224	-2.779189	-2.792769	-2.80733
AR(5)	-2.770918	-2.781244	-2.77874	-2.808282	-2.805984	-2.807537

**Table 158: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 01-02 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.865386	-2.864074	-2.863005	-2.862948	-2.879175	-2.885114
AR(1)	-2.864129	-2.879123	-2.880828	-2.909658	-2.896645	-2.906888
AR(2)	-2.862063	-2.88069	-2.866682	-2.909279	-2.912275	-2.910414
AR(3)	-2.863838	-2.910721	-2.908242	-2.917171	-2.911384	-2.908589
AR(4)	-2.875144	-2.908485	-2.914617	-2.91525	-2.915647	-2.915603
AR(5)	-2.877625	-2.90718	-2.911965	-2.918167	-2.922173	-2.937465

**Table 159: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 02-03 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.942332	-2.940108	-2.937246	-2.937277	-2.952088	-2.955297
AR(1)	-2.940056	-2.945226	-2.942477	-2.969373	-2.967768	-2.965205
AR(2)	-2.937232	-2.942472	-2.953803	-2.970403	-2.972888	-2.966244
AR(3)	-2.936562	-2.969619	-2.969174	-2.962964	-2.968661	-2.97226
AR(4)	-2.943111	-2.968095	-2.97335	-2.972221	-2.966705	-3.014505
AR(5)	-2.947287	-2.965313	-2.963826	-2.967923	-2.955006	-2.991567

**Table 160: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 03-04 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-3.023781	-3.021223	-3.025638	-3.02426	-3.03117	-3.03453
AR(1)	-3.021181	-3.018338	-3.043701	-3.040871	-3.038085	-3.044326
AR(2)	-3.023037	-3.045315	-3.044953	-3.051207	-3.037891	-3.038708
AR(3)	-3.022972	-3.04245	-3.029878	-3.028876	-3.031694	-3.036905
AR(4)	-3.028513	-3.039599	-3.048858	-3.047327	-3.043391	-3.036466
AR(5)	-3.029451	-3.044978	-3.036153	-3.027646	-3.035704	-3.051413

**Table 161: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 04-05 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.949891	-2.947375	-2.944855	-2.959437	-2.962251	-2.964025
AR(1)	-2.947305	-2.94454	-2.967446	-2.967779	-2.969985	-2.971985
AR(2)	-2.944538	-2.967698	-2.968954	-2.971816	-2.964277	-2.965345
AR(3)	-2.956841	-2.96854	-2.971745	-2.961902	-2.964296	<b>-2.974898</b>
AR(4)	-2.959119	-2.969856	-2.965765	-2.956857	-2.95782	-2.965438
AR(5)	-2.961403	-2.9605	-2.971573	-2.97144	-2.968666	-2.965088

Table 162: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 05-06 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.943354	-2.943683	-2.940664	-2.946004	-2.981097	-2.984047
AR(1)	-2.943693	-2.940739	-2.9379	-2.9744	-2.983171	-2.98142
AR(2)	-2.940762	-2.937825	-2.956337	-2.984603	-2.980576	-2.982647
AR(3)	-2.9411	-2.97519	-2.982157	-2.98832	-2.984523	-2.985329
AR(4)	-2.970381	-2.983009	-2.982695	-2.981047	-2.988	-2.991416
AR(5)	-2.973878	-2.9906	-2.981612	-2.978701	<b>-2.992019</b>	-2.983476

Table 163: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 06-07 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-3.14151	-3.140392	-3.14134	-3.144339	-3.159376	-3.160317
AR(1)	-3.140621	-3.137133	-3.139619	-3.172538	-3.17088	-3.168448
AR(2)	-3.139441	-3.137982	-3.172895	-3.170533	-3.172289	-3.169358
AR(3)	-3.144684	-3.17701	-3.168651	-3.169733	-3.169489	-3.167442
AR(4)	-3.154363	-3.168658	-3.17064	-3.169592	-3.166919	-3.164522
AR(5)	-3.15181	-3.168665	-3.169044	<b>-3.177317</b>	-3.16588	-3.169965

Table 164: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 07-08 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.987266	-2.988675	-2.988503	-2.991647	-3.014303	-3.017826
AR(1)	-2.988242	-2.990912	-3.025495	-3.02459	-3.026742	-3.023895
AR(2)	-2.988467	-3.027264	-3.006324	-3.023772	-3.026734	-3.024149
AR(3)	-2.989589	-3.026065	-3.023759	-3.025306	-3.024699	-3.021973
AR(4)	-3.004635	-3.025287	-3.027757	<b>-3.03176</b>	-3.031349	-3.028545
AR(5)	-3.007139	-3.023736	-3.024919	-3.023342	-3.028539	-3.021367

Table 165: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 08-09 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.981401	-2.979047	-2.976425	-2.977669	-2.994595	-3.008072
AR(1)	-2.979035	-2.9762	-3.004296	-3.006148	-3.010392	-3.009457
AR(2)	-2.976449	-3.00576	-3.008511	-2.99691	-2.966208	-3.006768
AR(3)	-2.976705	-3.008202	-3.00363	-3.004564	-3.004464	-3.005178
AR(4)	-2.989422	-3.00804	-3.005888	-3.003067	-3.005287	-3.002714
AR(5)	-2.999793	-3.005726	-3.004035	<b>-3.018928</b>	-3.008548	-3.007462

Table 166: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 09-10 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.851515	-2.849454	-2.846665	-2.845738	-2.85336	-2.861095
AR(1)	-2.849502	-2.86099	-2.859334	-2.859311	-2.860977	-2.859851
AR(2)	-2.846658	-2.859526	-2.856769	-2.858282	-2.858997	-2.857048
AR(3)	-2.844371	-2.860118	-2.859519	-2.842496	-2.85758	<b>-2.872644</b>
AR(4)	-2.848253	-2.860214	-2.857563	-2.866059	-2.855171	-2.863459
AR(5)	-2.85406	-2.857404	-2.859763	-2.864613	-2.862677	-2.867413

**Table 167: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 10-11 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.716468	-2.727446	-2.724868	-2.734889	-2.751116	-2.758731
AR(1)	-2.726913	-2.763605	-2.761566	-2.763706	-2.764898	-2.762399
AR(2)	-2.724123	-2.761806	-2.773909	-2.762098	-2.762228	-2.759634
AR(3)	-2.723074	-2.762959	-2.732218	<b>-2.805533</b>	-2.799389	-2.785559
AR(4)	-2.733774	-2.761814	-2.763805	-2.800009	-2.76429	-2.755064
AR(5)	-2.742179	-2.760163	-2.733436	-2.797535	-2.789871	-2.762426

**Table 168: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 11-12 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.670971	-2.684052	-2.681527	-2.706523	-2.702401	-2.734616
AR(1)	-2.684006	-2.718907	-2.706252	-2.731018	-2.72796	-2.73653
AR(2)	-2.681484	-2.721424	-2.723145	-2.734936	-2.723852	-2.742883
AR(3)	-2.689837	-2.734253	-2.720079	<b>-2.762525</b>	-2.722982	-2.741395
AR(4)	-2.694451	-2.730451	-2.725806	-2.725356	-2.724394	-2.752912
AR(5)	-2.706616	-2.723537	-2.722413	-2.728286	-2.749521	-2.737169

**Table 169: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 12-13 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.591518	-2.602154	-2.601056	-2.623532	-2.630574	-2.651587
AR(1)	-2.60374	-2.607517	-2.638068	-2.65247	-2.652445	-2.653755
AR(2)	-2.604269	-2.62978	-2.642143	-2.652463	-2.653631	-2.653056
AR(3)	-2.613085	-2.654153	-2.651559	-2.707634	-2.705503	-2.668396
AR(4)	-2.624522	-2.651696	-2.650264	-2.705662	-2.639972	-2.666144
AR(5)	-2.633715	-2.650975	-2.649421	-2.665023	-2.662101	<b>-2.722526</b>

**Table 170: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 13-14 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.623145	-2.630557	-2.633587	-2.653163	-2.65211	-2.669959
AR(1)	-2.632676	-2.640028	-2.662035	-2.677353	-2.675969	-2.674827
AR(2)	-2.637594	-2.639522	-2.668018	-2.676869	-2.675481	-2.674808
AR(3)	-2.64659	-2.667345	-2.675956	-2.72016	-2.719839	-2.684595
AR(4)	-2.652225	-2.676509	-2.678518	-2.720731	-2.700125	-2.683329
AR(5)	-2.654181	-2.674898	-2.668599	-2.766407	-2.731101	<b>-2.784017</b>

**Table 171: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 14-15(Period 2010-12)**



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.520067	-2.536963	-2.534874	-2.573491	-2.588052	-2.602247
AR(1)	-2.536808	-2.53527	-2.532582	-2.61129	-2.608888	-2.606283
AR(2)	-2.534407	-2.532449	-2.595017	-2.608805	-2.609747	-2.616169
AR(3)	-2.544286	-2.606797	-2.604151	-2.607168	-2.606757	-2.644303
AR(4)	-2.564716	-2.604441	-2.607194	-2.670698	-2.66863	-2.700036
AR(5)	-2.5734	-2.611613	-2.610229	-2.589188	-2.580408	<b>-2.733844</b>

Table 172: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 15-16 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.453024	-2.471659	-2.470267	-2.503125	-2.511067	-2.527891
AR(1)	-2.471049	-2.522511	-2.521343	-2.533283	-2.530583	-2.529183
AR(2)	-2.46832	-2.522025	-2.51131	-2.530623	-2.527821	-2.526842
AR(3)	-2.477754	-2.531147	-2.528463	-2.602278	-2.605575	-2.56937
AR(4)	-2.492792	-2.528702	-2.540553	-2.587487	-2.526233	-2.50554
AR(5)	-2.503016	-2.530425	-2.559298	-2.507565	-2.597298	<b>-2.651376</b>

Table 173: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 16-17 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.401189	-2.417964	-2.416269	-2.440726	-2.45118	-2.468447
AR(1)	-2.418939	-2.419112	-2.416866	-2.485642	-2.482823	-2.480132
AR(2)	-2.419579	-2.451992	-2.496106	-2.482824	-2.48776	-2.486634
AR(3)	-2.424901	-2.476167	-2.473355	-2.480013	-2.496389	-2.491708
AR(4)	-2.455791	-2.473369	-2.494033	-2.538787	-2.539443	-2.537304
AR(5)	-2.457723	-2.492239	-2.509484	-2.507485	-2.53768	<b>-2.628872</b>

Table 174: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 17-18 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.398168	-2.433743	-2.431083	-2.439222	-2.446054	-2.453506
AR(1)	-2.434887	-2.432276	-2.429769	-2.505197	-2.502402	-2.502842
AR(2)	-2.432222	-2.45674	-2.452032	-2.502312	-2.512737	-2.502619
AR(3)	-2.430702	-2.500908	-2.498261	-2.48861	-2.502133	-2.564248
AR(4)	-2.439435	-2.498157	-2.565575	-2.4937	-2.504276	-2.61402
AR(5)	-2.43945	-2.507126	-2.494762	-2.490081	<b>-2.626734</b>	-2.609622

Table 175: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 18-19 (Period 2010-12)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-2.627708	-2.66102	-2.658507	-2.679003	-2.695166	-2.717298
AR(1)	-2.663279	-2.661389	-2.658846	-2.72834	-2.726466	-2.716488
AR(2)	-2.66102	-2.658643	-2.723459	-2.725963	-2.72394	-2.714439
AR(3)	-2.662421	-2.726652	-2.723867	-2.775379	-2.774588	-2.734419
AR(4)	-2.675931	-2.723878	-2.72379	-2.720149	-2.779754	-2.734717
AR(5)	-2.682111	-2.729909	-2.727442	-2.735655	-2.757303	<b>-2.786812</b>

**Table 176: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 19-20 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.572554	-2.587815	-2.585991	-2.602997	-2.610318	-2.628737
AR(1)	-2.58693	-2.639316	-2.644624	-2.644131	-2.643482	-2.633022
AR(2)	-2.584238	-2.646158	-2.645572	-2.645339	-2.63958	-2.636772
AR(3)	-2.588163	-2.645013	-2.641896	-2.742972	-2.739853	-2.643964
AR(4)	-2.59337	-2.642392	-2.643594	-2.740428	-2.703024	-2.641962
AR(5)	-2.598534	-2.642282	-2.64607	-2.650399	-2.654583	<b>-2.747214</b>

**Table 177: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 20-21 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.65751	-2.669441	-2.672074	-2.68393	-2.698261	-2.708902
AR(1)	-2.667751	-2.720846	-2.718266	-2.713253	-2.71191	-2.712079
AR(2)	-2.669499	-2.718189	-2.711324	-2.720981	-2.724063	-2.718765
AR(3)	-2.67147	-2.714789	-2.707236	-2.722374	-2.681002	-2.729441
AR(4)	-2.676647	-2.714117	-2.724925	-2.724043	<b>-2.738077</b>	-2.716282
AR(5)	-2.686402	-2.713668	-2.719992	-2.717798	-2.714226	-2.720036

**Table 178: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 21-22 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.832854	-2.83705	-2.838395	-2.850606	-2.86378	-2.867489
AR(1)	-2.836272	-2.877643	-2.875237	-2.877011	-2.875086	-2.873786
AR(2)	-2.835228	-2.875346	-2.889228	-2.87077	-2.880283	-2.873784
AR(3)	-2.837872	-2.878433	-2.878867	-2.884536	-2.8801	-2.877869
AR(4)	-2.84493	-2.876601	-2.876507	-2.904194	<b>-2.906227</b>	-2.872386
AR(5)	-2.848525	-2.874267	-2.866672	-2.875526	-2.872738	-2.875571

**Table 179: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 22-23 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.932801	-2.931137	-2.930461	-2.950413	-2.954547	-2.955969
AR(1)	-2.930998	-2.962346	-2.961883	-2.964892	-2.962451	-2.960152
AR(2)	-2.928896	-2.962497	-2.974863	-2.962797	-2.961787	-2.977656
AR(3)	-2.938805	-2.959419	-2.963486	-2.961026	-2.959997	-2.957555
AR(4)	-2.939448	-2.962987	-2.97579	<b>-2.998926</b>	-2.961442	-2.998415
AR(5)	-2.940025	-2.961148	-2.977225	-2.997285	-2.998816	-2.97881

**Table 180: AIC values for ARMA parameters in Equation 1 (Model IIB) for Hour 23-24 (Period 2010-12)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0)	-2.816553	-2.814441	-2.816564	-2.83263	-2.847201	-2.847243
AR(1)	-2.814361	-2.858361	-2.859343	-2.858166	-2.855545	-2.853213
AR(2)	-2.814038	-2.859744	-2.856935	-2.855451	-2.855921	-2.863203
AR(3)	-2.818547	-2.85816	-2.855389	-2.852784	-2.892274	-2.889528
AR(4)	-2.827328	-2.855383	-2.855086	<b>-2.892391</b>	-2.889516	-2.860475
AR(5)	-2.828618	-2.853406	-2.85495	-2.867723	-2.864617	-2.859848

Table 181 reports the results of the estimation for the period 2010-12.

**Table 181: Results of Model IIB –Equation 1 and Equation 5 (2010-12)**

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
00-01	<b>-0.0113</b> (0.0017)	(3,5)		<b>0.0166</b> (0.0005)	0.0004 (0.5784)	<b>0.4469</b> (0.0000)	<b>0.1559</b> (0.0077)	<b>-0.0005</b> (0.0625)	<b>0.0008</b> (0.0078)
		<b>0.7449</b> (0.0000)	<b>-0.105</b> (0.0159)						
01-02	<b>-0.0179</b> (0.0000)	(5,5)		<b>0.0248</b> (0.0000)	-0.0006 (0.241)	<b>0.4651</b> (0.0000)	<b>-0.0637</b> (0.0082)	0.0002 (0.3413)	<b>0.0014</b> (0.0000)
		<b>0.6778</b> (0.0000)	<b>-0.8241</b> (0.0000)						
02-03	<b>-0.014</b> (0.0000)	(4,5)		<b>0.0197</b> (0.0000)	5.81E-05 (0.8982)	<b>0.3644</b> (0.0000)	<b>-0.1344</b> (0.0001)	<b>0.0003</b> (0.0408)	<b>0.0011</b> (0.0000)
		<b>0.7726</b> (0.0000)	0.0369 (0.3692)						
03-04	<b>-0.0159</b> (0.0000)	(5,5)		<b>0.0226</b> (0.0000)	<b>0.0011</b> (0.055)	<b>0.3267</b> (0.0000)	0.1087 (0.2848)	<b>0.0005</b> (0.0076)	5.21E-05 (0.8482)
		<b>0.422</b> (0.0000)	<b>-0.3185</b> (0.0000)						
04-05	<b>-0.0159</b> (0.0000)	(3,5)		<b>0.0223</b> (0.0000)	<b>0.0035</b> (0.0001)	<b>0.2557</b> (0.0001)	-0.0263 (0.8227)	1.26E-05 (0.9598)	-0.0006 (0.0733)
		<b>-0.4438</b> (0.012)	<b>0.1231</b> (0.0044)						
05-06	<b>-0.0139</b> (0.0000)	(5,4)		<b>0.0196</b> (0.0000)	<b>0.0017</b> (0.0000)	<b>0.2767</b> (0.0000)	<b>0.5508</b> (0.0000)	<b>-0.0004</b> (0.0309)	<b>-0.0003</b> (0.0029)
		0.0409 (0.3485)	<b>-0.7249</b> (0.0000)						
06-07	<b>-0.0185</b> (0.0000)	(5,3)		<b>0.0254</b> (0.0000)	<b>0.0013</b> (0.0000)	<b>0.28</b> (0.0000)	<b>0.48</b> (0.0000)	<b>-0.0003</b> (0.0347)	<b>-0.0002</b> (0.0177)
		<b>-0.1127</b> (0.0115)	<b>-0.8182</b> (0.0000)						
07-08	<b>-0.0187</b> (0.0000)	(4,3)		<b>0.0257</b> (0.0000)	<b>0.0005</b> (0.0001)	0.0098 (0.1918)	<b>0.9089</b> (0.0000)	<b>-0.0006</b> (0.0005)	<b>6.74E-05</b> (0.0154)
		<b>-0.1483</b> (0.0004)	<b>-0.8888</b> (0.0000)						
08-09	<b>-0.0231</b> (0.0000)	(5,3)		<b>0.0324</b> (0.0000)	<b>0.0017</b> (0.0011)	<b>0.3307</b> (0.0000)	<b>0.1869</b> (0.0354)	<b>-0.0006</b> (0.0018)	0.0001 (0.5249)
		<b>-0.0881</b> (0.0499)	<b>-0.8728</b> (0.0000)						
09-10	<b>-0.0258</b> (0.0000)	(3,5)		<b>0.0364</b> (0.0000)	<b>0.0007</b> (0.0158)	<b>0.2011</b> (0.0000)	<b>0.5002</b> (0.0000)	<b>-0.0015</b> (0.0000)	<b>0.0006</b> (0.0000)
		<b>0.6903</b> (0.0000)	-0.0513 (0.3422)						
10-11	<b>-0.0289</b> (0.0000)	(3,3)		<b>0.0405</b> (0.0000)	<b>0.0015</b> (0.0325)	<b>0.4979</b> (0.0000)	<b>0.2334</b> (0.0000)	<b>-0.0013</b> (0.0000)	0.0003 (0.2382)
		<b>0.8018</b> (0.0000)	<b>-0.8939</b> (0.0000)						

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
11-12	<b>-0.0314</b> (0.0000)	(3,3)		<b>0.0452</b> (0.0000)	<b>0.0007</b> (0.0146)	<b>0.3973</b> (0.0000)	<b>0.3726</b> (0.0000)	<b>-0.0017</b> (0.0000)	<b>0.0007</b> (0.0000)
		<b>0.7503</b> (0.0000)	<b>-0.8236</b> (0.0000)						
12-13	<b>-0.0438</b> (0.0000)	(5,5)		<b>0.0617</b> (0.0000)	<b>0.0011</b> (0.0214)	<b>0.465</b> (0.0000)	<b>0.372</b> (0.0000)	<b>-0.001</b> (0.0001)	0.0002 (0.0851)
		<b>0.7961</b> (0.0000)	<b>-0.8334</b> (0.0000)						
13-14	<b>-0.0532</b> (0.0000)	(5,5)		<b>0.0745</b> (0.0000)	0.0013 (0.0628)	<b>0.526</b> (0.0000)	<b>0.231</b> (0.0003)	<b>-0.001</b> (0.0014)	0.0002 (0.297)
		<b>0.8749</b> (0.0000)	<b>-0.8835</b> (0.0000)						
14-15	<b>-0.0578</b> (0.0000)	(5,5)		<b>0.0805</b> (0.0000)	<b>0.0025</b> (0.0001)	<b>0.3864</b> (0.0000)	<b>0.4205</b> (0.0000)	<b>-0.0019</b> (0.0000)	1.91E-05 (0.9352)
		<b>0.7804</b> (0.0000)	<b>-0.8732</b> (0.0000)						
15-16	<b>-0.0498</b> (0.0000)	(5,5)		<b>0.0685</b> (0.0000)	<b>0.0019</b> (0.0002)	<b>0.3614</b> (0.0000)	<b>0.6123</b> (0.0000)	<b>-0.0017</b> (0.0000)	-7.23E-05 (0.6767)
		<b>0.775</b> (0.0000)	<b>-0.8906</b> (0.0000)						
16-17	<b>-0.0593</b> (0.0000)	(5,5)		<b>0.0827</b> (0.0000)	9.20E-05 (0.8519)	0.3874 (0.0000)	<b>0.4905</b> (0.0000)	<b>-0.0002</b> (0.2128)	<b>0.0004</b> (0.0264)
		<b>0.8502</b> (0.0000)	<b>-0.8197</b> (0.0000)						
17-18	<b>-0.0401</b> (0.0000)	(5,4)		<b>0.0562</b> (0.0000)	0.0001 (0.8419)	<b>1.0571</b> (0.0000)	0.0425 (0.2153)	0.0004 (0.1251)	0.0004 (0.0989)
		<b>0.2458</b> (0.0000)	<b>-0.8221</b> (0.0000)						
18-19	<b>-0.0334</b> (0.0000)	(5,5)		<b>0.0462</b> (0.0000)	0.0012 (0.0546)	<b>0.4161</b> (0.0000)	<b>0.4931</b> (0.0000)	-0.0002 (0.3954)	-0.0001 (0.4061)
		<b>0.6725</b> (0.0000)	<b>-0.8211</b> (0.0000)						
19-20	<b>-0.0309</b> (0.0000)	(5,5)		<b>0.0433</b> (0.0000)	<b>0.0021</b> (0.0233)	<b>0.5676</b> (0.0000)	<b>0.2122</b> (0.0000)	-0.0004 (0.1155)	-0.0001 (0.6409)
		<b>0.6591</b> (0.0000)	<b>-0.8151</b> (0.0000)						
20-21	<b>-0.0333</b> (0.0000)	(4,4)		<b>0.0462</b> (0.0000)	<b>0.0011</b> (0.0048)	<b>0.1017</b> (0.0005)	<b>0.7449</b> (0.0000)	<b>-0.0005</b> (0.0441)	-6.88E-05 (0.5172)
		<b>-0.6914</b> (0.0000)	<b>0.8673</b> (0.0000)						
21-22	<b>-0.0248</b> (0.0000)	(4,4)		<b>0.0345</b> (0.0000)	0.0001 (0.6625)	<b>0.131</b> (0.0001)	<b>0.68</b> (0.0000)	0.0002 (0.348)	0.0001 (0.1076)
		<b>-0.6623</b> (0.0000)	<b>0.6552</b> (0.0000)						
22-23	<b>-0.0226</b> (0.0000)	(4,3)		<b>0.0313</b> (0.0000)	-0.0002 (0.3435)	<b>0.1484</b> (0.0000)	<b>0.6599</b> (0.0000)	0.0003 (0.1198)	<b>0.0002</b> (0.0052)
		<b>-0.1112</b> (0.0144)	<b>-0.8654</b> (0.0000)						

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
23-24	<b>-0.0165</b> (0.0000)	(4,3)		<b>0.0223</b> (0.0000)	0.0005 (0.164)	<b>0.2305</b> (0.0000)	<b>0.5706</b> (0.0000)	<b>0.0005</b> (0.0051)	-0.0001 (0.4764)
		<b>-0.0962</b> (0.0259)	<b>-0.9221</b> (0.0000)						

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

Table 181 describes the result of the estimation of Model IIB for the set of time period 1 April 2010 to 31 March 2012. In the mean equation, the coefficients of the dummy variable ( $\beta_2$ ) are significant for all the twenty four hours. In the variance equation, ARCH effects ( $\beta_4$ ) remain significant for all the hours except hour 07-08 and 16-17 while GARCH effects ( $\beta_5$ ) are significant for all hours except hour 03-04, 04-05, and 17-18. While in the variance equation (Equation 5), with respect to the effect of dummy variable ( $\beta_6$ ) on the return volatility, we find that the dummy variable is significant for seventeen hours out of the twenty four hours. The weekday effect is not significant for seven hours out of the twenty four hours (01-02, 02-03, 04-05, 08-09, 22-23, and 23-24). The coefficient of volume ( $\beta_7$ ) (lagged log of volume) is significant for eleven hours out of the twenty four hours (00-01, 01-02, 02-03, 05-06, 06-07, 07-08, 08-09, 09-10, 11-12, 16-17, 22-23). The volume effects are insignificant in case of thirteen hours out of twenty four hours, it can be concluded that information does not flow at the same time of auction. Participants at the power exchange purchase or sell electricity contracts depending on their requirement.

The AIC values for ARMA parameters in mean equation (Equation 1 of Model IIB) are reported for hours in Table 182 to Table 205 for the period 2012-14. Table 206 reports the results of the estimation for the period 2012-14.

**Table 182: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 00-01 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.575668	-1.573176	-1.575615	-1.57682	-1.581315	-1.579688
AR(1)	-1.573062	-1.575701	-1.578041	-1.575864	-1.628171	-1.626729
AR(2)	-1.574434	-1.577928	-1.626148	-1.623731	-1.62716	-1.624399
AR(3)	-1.57677	-1.576527	-1.623261	-1.627881	-1.622578	-1.630896
AR(4)	-1.583142	-1.629958	-1.628241	-1.629188	-1.632281	<b>-1.6324</b>
AR(5)	-1.580377	-1.573322	-1.582235	-1.623197	-1.621558	-1.620202

**Table 183: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 01-02 (Period 2012-14)**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.61888	-1.616296	-1.614982	-1.613141	-1.616608	-1.614779
AR(1)	-1.616304	-1.658396	-1.613451	-1.611631	-1.655085	-1.611781
AR(2)	-1.614773	-1.656258	-1.653632	-1.653508	-1.651474	-1.624475
AR(3)	-1.613705	-1.5992	-1.613831	-1.61653	-1.656759	-1.656019
AR(4)	-1.618439	-1.656355	-1.664145	-1.667821	-1.659182	<b>-1.668597</b>
AR(5)	-1.616341	-1.656561	-1.609592	-1.621632	-1.624727	-1.665851

Table 184: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 02-03 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.681313	-1.678939	-1.681199	-1.678448	-1.682775	-1.681143
AR(1)	-1.678726	<b>-1.725733</b>	-1.72346	-1.678568	-1.720069	-1.71406
AR(2)	-1.680437	-1.723425	-1.724403	-1.72182	-1.717577	-1.716105
AR(3)	-1.677732	-1.678161	-1.700123	-1.667355	-1.711821	-1.711575
AR(4)	-1.680077	-1.719609	-1.715735	-1.725049	-1.721831	-1.725712
AR(5)	-1.677675	-1.718691	-1.716249	-1.714797	-1.705244	-1.707007

Table 185: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 03-04 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.624874	-1.625946	-1.624057	-1.621958	-1.6215	-1.61884
AR(1)	-1.625086	-1.654328	-1.652157	-1.649421	-1.64661	-1.643145
AR(2)	-1.623244	-1.652185	-1.641819	-1.655978	-1.644	-1.641485
AR(3)	-1.621228	-1.649422	-1.65593	<b>-1.665399</b>	-1.641004	-1.641353
AR(4)	-1.619808	-1.64667	-1.642777	-1.640388	-1.658545	-1.659846
AR(5)	-1.617271	-1.643936	-1.64009	-1.647309	-1.644581	-1.648126

Table 186: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 04-05 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.55669	-1.554936	-1.563403	-1.561021	-1.561143	-1.558381
AR(1)	-1.554348	-1.589716	-1.586981	-1.565776	-1.562255	-1.586481
AR(2)	-1.562721	-1.586971	-1.595317	-1.564794	-1.58766	-1.58219
AR(3)	-1.56003	-1.566079	-1.563347	-1.58775	-1.568089	-1.572322
AR(4)	-1.558169	-1.587805	-1.59182	-1.602293	<b>-1.606857</b>	-1.590707
AR(5)	-1.555487	-1.585039	-1.583705	-1.575601	-1.60566	-1.602677

Table 187: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 05-06 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.629521	-1.629973	-1.627366	-1.62684	-1.628041	-1.626866
AR(1)	-1.629812	-1.677763	-1.675065	-1.627503	-1.677828	-1.675065
AR(2)	-1.627488	-1.675071	-1.676092	-1.67388	-1.674945	-1.680675
AR(3)	-1.6269	-1.62267	-1.67396	-1.623253	-1.635513	<b>-1.684519</b>
AR(4)	-1.627559	-1.624822	-1.675351	-1.672525	-1.671157	-1.637101
AR(5)	-1.625012	-1.624535	-1.675502	-1.640888	-1.632927	-1.619557

Table 188: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 06-07 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.695697	-1.693083	-1.692151	-1.69126	-1.688505	-1.689962
AR(1)	-1.693068	-1.696377	-1.717258	-1.714496	-1.713531	-1.708345
AR(2)	-1.692207	-1.717261	-1.716426	-1.719359	-1.716592	-1.707299
AR(3)	-1.690553	-1.716239	-1.719264	-1.716629	-1.715923	-1.724403
AR(4)	-1.687787	-1.713508	-1.709046	-1.71587	-1.715526	-1.723849
AR(5)	-1.688721	-1.71148	-1.708929	-1.724424	-1.7261	<b>-1.734737</b>

Table 189: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 07-08 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.7711	-1.76887	-1.768674	-1.772436	-1.769941	-1.767176
AR(1)	-1.768649	-1.767644	-1.767939	-1.769771	-1.767619	-1.794176
AR(2)	-1.768215	-1.768575	-1.771384	-1.768843	-1.766632	-1.779874
AR(3)	-1.772184	-1.769894	-1.76885	-1.767167	-1.764415	-1.795399
AR(4)	-1.769997	-1.76833	-1.767001	<b>-1.802362</b>	-1.800001	-1.786217
AR(5)	-1.767243	-1.766197	-1.777942	-1.77553	-1.785169	-1.79613

Table 190: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 08-09 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.621378	-1.620351	-1.618557	-1.617715	-1.617025	-1.616781
AR(1)	-1.620328	-1.617585	-1.615813	-1.616621	-1.614995	-1.614368
AR(2)	-1.618504	-1.615823	-1.627327	-1.627798	-1.62122	-1.623611
AR(3)	-1.618392	-1.616259	-1.627173	<b>-1.631878</b>	-1.622172	-1.630341
AR(4)	-1.616598	-1.613955	-1.625061	-1.61742	-1.6277	-1.620798
AR(5)	-1.614119	-1.611536	-1.619289	-1.630959	-1.618667	-1.619909

Table 191: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 09-10 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.420665	-1.429012	-1.426752	-1.427446	-1.425514	-1.427424
AR(1)	-1.428972	-1.428689	-1.42554	-1.424685	-1.427343	-1.437724
AR(2)	-1.4271	-1.425526	-1.423817	-1.422369	-1.416416	-1.459198
AR(3)	-1.426597	-1.424893	-1.421699	-1.474184	-1.469143	-1.438153
AR(4)	-1.424764	-1.437383	-1.458957	-1.422072	-1.466684	-1.462915
AR(5)	-1.43691	-1.450235	-1.447017	-1.45894	-1.463788	<b>-1.477574</b>

Table 192: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 10-11 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.311427	-1.327025	-1.324531	-1.325418	-1.322688	-1.320002
AR(1)	-1.326136	-1.336896	-1.324751	-1.339529	-1.336249	-1.327419
AR(2)	-1.323764	-1.32517	-1.33644	-1.340456	-1.339229	-1.340664
AR(3)	-1.323915	-1.339884	-1.328546	-1.3553	-1.371287	-1.353096
AR(4)	-1.322387	-1.333045	-1.341358	-1.38109	-1.37682	-1.379125
AR(5)	-1.320448	-1.331994	-1.346417	-1.379579	-1.378836	<b>-1.382336</b>

Table 193: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 11-12 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.199742	-1.232275	-1.232268	-1.229947	-1.225004	-1.222473
AR(1)	-1.22685	-1.230321	-1.222982	-1.2274	-1.2225	-1.220661
AR(2)	-1.226434	-1.223875	-1.216681	-1.214137	-1.220181	-1.220888
AR(3)	-1.226986	-1.226243	-1.223959	-1.22572	-1.220589	-1.238131
AR(4)	-1.224576	-1.219233	-1.222507	-1.22964	-1.220032	-1.240463
AR(5)	-1.219488	-1.222756	-1.217077	-1.22032	-1.225236	<b>-1.258561</b>

Table 194: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 12-13 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.161896	-1.194844	-1.195045	-1.199918	-1.197299	-1.194704
AR(1)	-1.189696	-1.19953	-1.195106	-1.212992	-1.210452	-1.211491
AR(2)	-1.18958	-1.192048	-1.197642	-1.209437	-1.210807	-1.209501
AR(3)	-1.193762	-1.217312	-1.214844	-1.198534	-1.232282	-1.260668
AR(4)	-1.198081	-1.217035	-1.212372	-1.255995	-1.196333	-1.216429
AR(5)	-1.195844	-1.214294	-1.219959	<b>-1.262049</b>	-1.215948	-1.202888

Table 195: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 13-14 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.124814	-1.15686	-1.155651	-1.152921	-1.150414	-1.147747
AR(1)	-1.151517	-1.155951	-1.159159	-1.169605	-1.165587	-1.168322
AR(2)	-1.154179	-1.169551	-1.176106	-1.177128	-1.175147	-1.118727
AR(3)	-1.15205	-1.173662	-1.171308	-1.166844	-1.148889	-1.191812
AR(4)	-1.150052	-1.159471	-1.176127	-1.170157	-1.162936	-1.202098
AR(5)	-1.147653	-1.170107	-1.165034	-1.216694	-1.169728	<b>-1.260129</b>

Table 196: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 14-15(Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.13637	-1.169025	-1.173348	-1.170628	-1.168875	-1.169331
AR(1)	-1.161125	-1.173351	-1.170735	-1.17498	-1.175658	-1.175775
AR(2)	-1.169935	-1.170745	-1.175536	-1.181862	-1.179305	-1.178882
AR(3)	-1.168922	-1.176531	-1.164199	-1.175814	-1.235351	-1.169963
AR(4)	-1.17024	-1.181714	<b>-1.260495</b>	-1.236941	-1.170002	-1.171373
AR(5)	-1.168684	-1.180952	-1.185743	-1.234175	-1.173396	-1.245514

Table 197: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 15-16 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.192248	-1.226812	-1.224052	-1.221868	-1.220262	-1.217502
AR(1)	-1.224453	-1.224053	-1.233452	-1.224727	-1.23553	-1.220162
AR(2)	-1.224602	-1.227961	-1.238186	-1.29734	-1.237678	-1.235289
AR(3)	-1.222137	-1.237726	-1.223133	-1.249748	-1.232497	-1.256372
AR(4)	-1.219499	-1.23547	-1.238406	<b>-1.302547</b>	-1.284886	-1.286803
AR(5)	-1.217093	-1.225968	-1.237718	-1.223499	-1.24846	-1.292978

Table 198: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 16-17 (Period 2012-14)



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.259982	-1.290883	-1.288178	-1.288299	-1.298934	-1.299031
AR(1)	-1.290573	-1.288231	-1.291323	-1.312532	-1.300674	-1.314438
AR(2)	-1.288141	-1.320326	-1.310457	-1.296634	-1.316506	-1.317683
AR(3)	-1.285387	-1.317466	-1.316728	-1.392673	-1.308686	-1.358483
AR(4)	-1.292725	-1.315848	-1.324094	-1.365323	<b>-1.43366</b>	-1.323698
AR(5)	-1.291145	-1.317417	-1.32757	-1.370584	-1.344335	-1.388825

Table 199: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 17-18 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.278948	-1.302628	-1.299879	-1.297683	-1.299229	-1.299919
AR(1)	-1.302062	-1.299897	-1.29948	-1.306953	-1.304921	-1.302269
AR(2)	-1.299851	-1.308375	-1.305932	-1.334576	-1.303888	-1.295431
AR(3)	-1.297093	-1.306202	-1.337801	-1.385949	-1.383206	-1.292617
AR(4)	-1.296261	-1.304709	-1.304664	-1.383246	-1.303127	-1.302156
AR(5)	-1.295141	-1.301967	-1.302347	-1.296721	-1.303353	<b>-1.391284</b>

Table 200: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 18-19 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.094757	-1.124718	-1.124692	-1.122647	-1.13033	-1.130067
AR(1)	-1.119908	-1.144625	-1.149611	-1.146925	-1.137266	-1.144365
AR(2)	-1.122987	-1.149558	-1.134339	-1.152529	-1.126979	-1.150286
AR(3)	-1.120323	-1.146985	-1.155161	<b>-1.204451</b>	-1.201811	-1.152778
AR(4)	-1.120465	-1.145863	-1.154695	-1.201775	-1.131602	-1.123716
AR(5)	-1.118653	-1.143125	-1.153011	-1.120963	-1.154656	-1.198787

Table 201: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 19-20 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.19081	-1.189772	-1.191264	-1.212512	-1.223629	-1.222819
AR(1)	-1.186514	-1.222613	-1.201501	-1.231522	-1.221261	-1.215055
AR(2)	-1.186003	-1.233451	-1.23297	-1.20953	-1.231872	-1.224449
AR(3)	-1.188287	-1.231779	-1.23634	-1.244277	-1.29554	-1.287919
AR(4)	-1.207425	-1.230731	-1.236112	-1.220274	-1.298397	-1.299014
AR(5)	-1.205292	-1.233462	-1.220879	-1.297094	-1.267074	<b>-1.304763</b>

Table 202: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 20-21 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.363654	-1.364666	-1.368241	-1.365571	-1.38518	-1.382455
AR(1)	-1.363602	-1.40831	-1.405977	-1.404064	-1.401668	-1.390277
AR(2)	-1.365062	-1.405924	-1.406995	-1.388458	-1.390267	-1.39607
AR(3)	-1.362296	-1.403918	-1.406567	-1.381501	-1.439339	-1.42332
AR(4)	-1.378583	-1.401591	-1.392362	-1.424142	-1.41762	-1.437475
AR(5)	-1.376078	-1.373785	-1.389832	-1.423289	-1.415934	<b>-1.444426</b>

Table 203: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 21-22 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.681482	-1.698284	-1.699311	-1.701823	-1.707143	-1.704527
AR(1)	-1.698109	-1.726815	-1.729013	-1.712224	-1.715851	-1.715181
AR(2)	-1.699232	-1.728578	-1.727409	-1.724711	-1.714115	-1.721555
AR(3)	-1.699874	-1.726384	-1.7217	<b>-1.752252</b>	-1.715084	-1.661927
AR(4)	-1.709644	-1.707221	-1.716734	-1.740441	-1.719443	-1.734486
AR(5)	-1.707877	-1.723544	-1.731313	-1.737719	-1.740677	-1.695355

Table 204: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 22-23 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.791541	-1.803184	-1.801405	-1.801833	-1.799866	-1.798759
AR(1)	-1.804652	-1.802943	-1.843712	-1.828743	-1.862515	-1.860453
AR(2)	-1.802438	-1.800364	-1.826502	-1.825838	-1.862813	-1.858311
AR(3)	-1.801246	-1.827947	-1.824022	-1.808979	-1.860082	-1.861199
AR(4)	-1.799441	-1.862059	-1.859195	-1.862984	-1.862292	-1.853881
AR(5)	-1.798065	-1.860895	-1.858781	<b>-1.8659</b>	-1.856191	-1.863973

Table 205: AIC values for ARMA parameters in Equation 1(Model IIB) for Hour 23-24 (Period 2012-14)

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.433245	-1.434704	-1.432636	-1.432474	-1.435507	-1.43842
AR(1)	-1.434726	-1.469867	-1.465974	-1.465938	-1.462999	-1.460619
AR(2)	-1.431809	-1.467942	-1.4652	-1.429069	-1.458058	-1.457772
AR(3)	-1.430605	-1.465899	-1.466663	-1.460684	-1.458296	-1.475351
AR(4)	-1.43047	-1.46282	-1.46035	-1.457979	<b>-1.478723</b>	-1.464024
AR(5)	-1.432656	-1.460154	-1.458337	-1.473583	-1.467779	-1.470942

Table 206: Results of Model IIB –Equation 1 and Equation 5 (2012-14)

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
00-01	-0.0069 (0.2047)	(4,5)		0.0092 (0.2275)	0.0014 (0.4095)	0.2725 (0.0000)	0.693 (0.0000)	-0.0012 (0.0037)	0.0001 (0.8441)
		0.3657 (0.0000)	0.0549 (0.1131)						
01-02	-0.0145 (0.0013)	(4,5)		0.0194 (0.0024)	-0.001 (0.1899)	0.3018 (0.0000)	0.7141 (0.0000)	-0.0014 (0.0006)	0.0008 (0.0000)
		0.421 (0.2232)	-0.0326 (0.6518)						
02-03	-0.0172 (0.0017)	(1,1)		0.0235 (0.0022)	0.0109 (0.0000)	0.299 (0.0000)	0.5836 (0.0000)	-0.0016 (0.0008)	-0.0028 (0.0001)
		0.9164 (0.0000)	-0.9966 (0.0000)						
03-04	-0.0212 (0.0002)	(3,3)		0.0293 (0.0002)	0.0084 (0.0000)	0.2317 (0.0000)	0.633 (0.0000)	-0.0009 (0.087)	-0.0021 (0.0004)
		0.9188 (0.0000)	-0.9916 (0.0000)						
04-05	-0.021 (0.0000)	(4,4)		0.0291 (0.0001)	0.0076 (0.0000)	0.2201 (0.0000)	0.6842 (0.0000)	0.0001 (0.7956)	-0.0022 (0.0002)
		0.5544 (0.0000)	-0.7132 (0.0000)						
05-06	-0.0278	(3,5)		0.0392	0.0033	0.2088	0.7065	0.0005	-0.0009

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
	(0.0000)	0.0403 (0.6162)	-0.1041 (0.0419)	(0.0000)	(0.0559)	(0.0000)	(0.0000)	(0.4814)	(0.1069)
06-07	-0.0364 (0.0000)	(5,5)		0.0517 (0.0000)	0.004 (0.0009)	0.2867 (0.0000)	0.6804 (0.0000)	-0.0031 (0.0003)	-0.0003 (0.3911)
		0.841 (0.0000)	-0.9239 (0.0000)						
07-08	-0.0427 (0.0000)	(4,3)		0.0599 (0.0000)	0.003 (0.0007)	0.2119 (0.0000)	0.7378 (0.0000)	-0.0021 (0.0019)	-0.0002 (0.1904)
		0.0485 (0.267)	-0.807 (0.0000)						
08-09	-0.0375 (0.0000)	(3,3)		0.0518 (0.0000)	-0.0015 (0.0294)	0.1891 (0.0000)	0.7862 (0.0000)	0.0001 (0.7967)	0.0006 (0.0000)
		0.8038 (0.0000)	-0.9163 (0.0000)						
09-10	-0.0425 (0.0000)	(5,5)		0.059 (0.0000)	0.0021 (0.0396)	0.109 (0.0000)	0.8443 (0.0000)	-0.0059 (0.0000)	0.0009 (0.0000)
		0.6449 (0.0000)	-0.573 (0.0000)						
10-11	-0.0667 (0.0000)	(5,5)		0.0932 (0.0000)	0.0066 (0.0364)	0.1804 (0.0000)	0.6418 (0.0000)	-0.0089 (0.0000)	0.0009 (0.3394)
		0.7482 (0.0000)	-0.7463 (0.0000)						
11-12	-0.0642 (0.0000)	(5,5)		0.0886 (0.0000)	0.0107 (0.0043)	0.199 (0.0000)	0.6257 (0.0000)	-0.0146 (0.0000)	0.0011 (0.3652)
		0.7265 (0.0000)	-0.7284 (0.0000)						
12-13	-0.0748 (0.0000)	(5,3)		0.1038 (0.0000)	0.0064 (0.0111)	0.152 (0.0000)	0.7003 (0.0000)	-0.0111 (0.0000)	0.0014 (0.0851)
		0.1136 (0.0165)	-0.9272 (0.0000)						
13-14	-0.0492 (0.0000)	(5,5)		0.0686 (0.0000)	0.0048 (0.1505)	0.1534 (0.0000)	0.7113 (0.0000)	-0.0106 (0.0000)	0.0018 (0.0804)
		0.8509 (0.0000)	-0.8606 (0.0000)						
14-15	-0.0541 (0.0000)	(4,2)		0.0802 (0.0000)	0.0157 (0.0000)	0.2857 (0.0000)	0.6348 (0.0000)	-0.0082 (0.0000)	-0.0024 (0.0247)
		-0.1777 (0.0001)	0.9605 (0.0000)						
15-16	-0.0639 (0.0000)	(4,3)		0.0893 (0.0000)	0.0091 (0.0055)	0.2442 (0.0000)	0.6684 (0.0000)	-0.0075 (0.0000)	-0.0004 (0.6395)
		0.0805 (0.0544)	-0.9696 (0.0000)						
16-17	-0.1324	(4,4)		0.1857	0.0029	0.3172	0.6607	-0.0028	0.0001

Hours	Mean Equation				Variance Equation				
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_2$	$\beta_3$	$\beta_4$	$\beta_5$	$\beta_6$	$\beta_7$
	(0.0000)	-0.9935 (0.0000)	0.9396 (0.0000)	(0.0000)	(0.2073)	(0.0000)	(0.0000)	(0.0027)	(0.8871)
17-18	<b>-0.0713</b> (0.0000)	(5,5)		<b>0.1025</b> (0.0000)	0.0122	<b>0.6487</b>	<b>0.2683</b>	-0.0013	-0.0023
		<b>0.8311</b> (0.0000)	<b>-0.8923</b> (0.0000)		(0.0789)	(0.0000)	(0.0000)	(0.1043)	(0.3257)
18-19	<b>-0.069</b> (0.0000)	(3,3)		<b>0.0966</b> (0.0000)	0.0007	<b>0.269</b>	<b>0.6789</b>	-0.0011	0.0006
		<b>0.8135</b> (0.0000)	<b>-0.9066</b> (0.0000)		(0.8131)	(0.0000)	(0.0000)	(0.1892)	(0.5425)
19-20	<b>-0.0459</b> (0.0000)	(5,5)		<b>0.0644</b> (0.0000)	0.0002	<b>0.5326</b>	<b>0.5779</b>	<b>-0.0034</b>	0.001
		<b>0.6601</b> (0.0000)	<b>-0.7437</b> (0.0000)		(0.9072)	(0.0000)	(0.0000)	(0.0002)	(0.2165)
20-21	<b>-0.0402</b> (0.0000)	(5,5)		<b>0.0559</b> (0.0000)	<b>-0.0016</b>	<b>0.3003</b>	<b>0.6597</b>	<b>-0.0048</b>	<b>0.0022</b>
		<b>0.6339</b> (0.0000)	<b>-0.826</b> (0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
21-22	<b>-0.0163</b> (0.0001)	(3,3)		<b>0.0226</b> (0.0001)	<b>-0.0035</b>	<b>0.416</b>	<b>0.6561</b>	4.23E-05	<b>0.0013</b>
		<b>0.7182</b> (0.0000)	<b>-0.8987</b> (0.0000)		(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.8216)
22-23	<b>-0.0122</b> (0.0000)	(5,3)		<b>0.0164</b> (0.0000)	-9.42E-05	<b>0.8013</b>	<b>0.4839</b>	<b>-0.0008</b>	0.0003
		-0.0434 (0.2668)	<b>-0.9749</b> (0.0000)		(0.9058)	(0.0000)	(0.0000)	(0.0000)	(0.1551)
23-24	<b>-0.0282</b> (0.0000)	(4,4)		<b>0.0385</b> (0.0000)	0.001	<b>0.3015</b>	<b>0.7071</b>	<b>-0.0029</b>	0.0005
		<b>0.7716</b> (0.0049)	<b>-0.8586</b> (0.0049)		(0.4941)	(0.0000)	(0.0000)	(0.0000)	(0.1468)

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

From Table 206, it is observed from the results of mean equation (Equation 1) that the coefficients of dummy variable ( $\beta_2$ ) are significant for all the twenty four hours. In the variance equation (Equation 5), ARCH effects ( $\beta_4$ ) and GARCH effects remain significant for all the twenty four hours. While in the variance equation (Equation 5), the coefficient of dummy variable ( $\beta_6$ ) on the return volatility, we find that the dummy variable is significant for twenty one hours out of the twenty four hours. It is found to be insignificant in case of three hours (17-18, 18-19, and 21-22). Whereas volume ( $\beta_7$ ) (lagged log of volume) is significant for thirteen hours out of the twenty four hours (00-01, 01-02, 02-03, 03-04, 04-05, 05-06, 06-07, 07-08, 08-

09, 09-10, 14-15, 20-21, 21-22). The volume effects are insignificant in case of eleven hours out of twenty four hours.

#### 4.2 The impact of introduction of fifteen minute day ahead electricity contracts

##### Model IIIA

In Model IIIA, we include a dummy variable ( $\beta_9$ ) (dummy takes the value 0 for period before 1 April 2012 and dummy takes the value 1 for period after 1 April 2012) in the mean equation (Equation 6). The AIC values for ARMA parameters in mean equation (Equation 6 of Model IIIA) are reported for hours in Table 207 to Table 230. Table 231 reports the results of the estimation.

**Table 207: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 00-01**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.276121	-1.274924	-1.275016	-1.278196	-1.288458	-1.293975
AR(1)	-1.274908	-1.274948	-1.312977	-1.308669	-1.307886	-1.311806
AR(2)	-1.274842	-1.309552	-1.30867	-1.307458	-1.307453	-1.317199
AR(3)	-1.275861	-1.308744	-1.30741	-1.272808	-1.306088	-1.311861
AR(4)	-1.28141	-1.307527	-1.307463	<b>-1.326486</b>	-1.30772	-1.312726
AR(5)	-1.284888	-1.31172	-1.306179	-1.311893	-1.311044	-1.309436

**Table 208: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 01-02**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.342357	-1.340965	-1.340038	-1.341197	-1.358966	-1.363042
AR(1)	-1.340964	-1.336675	-1.340081	-1.372653	-1.37388	-1.381171
AR(2)	-1.339892	-1.340109	-1.346272	-1.344904	-1.373304	<b>-1.383834</b>
AR(3)	-1.339816	-1.372918	-1.344904	-1.34539	-1.372078	-1.383304
AR(4)	-1.352004	-1.372757	-1.373245	-1.371855	-1.377226	-1.38186
AR(5)	-1.354314	-1.381245	-1.371856	-1.383286	-1.382029	-1.379191

**Table 209: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 02-03**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.436773	-1.435426	-1.435916	-1.43632	-1.448672	-1.451689
AR(1)	-1.435421	-1.438226	-1.477661	-1.476258	-1.473369	-1.477258
AR(2)	-1.43543	-1.477652	-1.480686	-1.479237	-1.478153	-1.476879
AR(3)	-1.434805	-1.476251	-1.478128	-1.438595	-1.475011	-1.467734
AR(4)	-1.441555	-1.474852	-1.478117	-1.472619	-1.472877	<b>-1.48179</b>
AR(5)	-1.444084	-1.47698	-1.476504	-1.467281	-1.469914	-1.465813

**Table 210: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 03-04**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.441435	-1.440045	-1.442223	-1.445408	-1.452324	-1.453274
AR(1)	-1.44004	-1.438648	-1.468848	-1.467441	-1.466121	-1.472301
AR(2)	-1.441237	-1.469171	-1.464608	-1.462931	-1.472233	-1.471737
AR(3)	-1.442812	-1.462442	-1.467314	-1.466381	-1.46754	<b>-1.478041</b>
AR(4)	-1.446377	-1.466407	-1.47223	-1.472086	-1.464719	-1.465013
AR(5)	-1.446225	-1.471852	-1.471831	-1.463365	-1.463883	-1.464174

Table 211: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 04-05

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.365352	-1.36459	-1.368528	-1.375411	-1.379266	-1.379589
AR(1)	-1.36446	-1.392528	-1.391711	-1.39032	-1.396093	-1.395572
AR(2)	-1.366869	-1.391815	-1.391062	-1.389527	-1.388157	-1.394817
AR(3)	-1.37127	-1.390427	-1.389533	-1.387532	<b>-1.400228</b>	-1.393123
AR(4)	-1.373375	-1.3954	-1.388199	-1.393572	-1.377656	-1.389071
AR(5)	-1.37421	-1.394737	-1.394993	-1.392563	-1.391658	-1.390368

Table 212: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 05-06

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.405863	-1.407021	-1.406017	-1.406077	-1.43034	-1.434971
AR(1)	-1.406942	-1.4554	-1.454049	-1.453832	-1.448032	-1.458236
AR(2)	-1.405813	-1.408474	-1.456432	-1.449214	-1.458659	-1.457591
AR(3)	-1.404752	-1.453508	-1.452072	-1.456867	-1.457756	-1.454632
AR(4)	-1.421338	-1.452912	-1.457205	-1.457475	-1.45839	-1.437556
AR(5)	-1.424455	-1.459573	-1.454653	-1.45383	<b>-1.459849</b>	-1.458218

Table 213: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 06-07

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.521702	-1.52177	-1.520441	-1.523368	-1.527885	-1.533572
AR(1)	-1.521722	-1.520376	-1.544706	-1.545086	-1.543762	-1.542512
AR(2)	-1.520551	-1.545235	-1.544427	-1.541604	-1.544586	-1.543327
AR(3)	-1.52257	-1.544926	-1.543555	-1.543666	-1.549234	-1.546773
AR(4)	-1.526483	-1.543618	-1.544199	-1.545259	-1.55122	-1.544236
AR(5)	-1.529906	-1.543273	-1.530816	<b>-1.561778</b>	-1.555949	-1.544259

Table 214: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 07-08

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.437823	-1.437193	-1.441609	-1.448285	-1.451823	-1.455682
AR(1)	-1.437059	-1.434384	-1.472019	-1.47062	-1.469244	-1.467846
AR(2)	-1.441254	-1.471869	-1.470618	-1.471806	-1.47084	-1.470557
AR(3)	-1.443487	-1.470636	-1.471936	<b>-1.49639</b>	-1.485685	-1.472881
AR(4)	-1.44528	-1.469235	-1.470709	-1.483982	-1.473097	-1.482468
AR(5)	-1.449357	-1.467832	-1.466655	-1.475745	-1.482453	-1.476031

Table 215: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 08-09

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.370815	-1.369618	-1.372153	-1.37273	-1.376025	-1.389118
AR(1)	-1.369589	-1.391964	-1.392197	-1.390813	-1.391344	-1.391235
AR(2)	-1.371496	-1.385336	-1.40581	-1.404416	-1.389976	-1.406727
AR(3)	-1.370509	-1.390757	-1.393065	-1.396387	-1.391015	<b>-1.425666</b>
AR(4)	-1.37161	-1.390591	-1.384884	-1.395983	-1.398434	-1.424269
AR(5)	-1.383572	-1.384687	-1.405684	-1.425328	-1.423999	-1.423986

**Table 216: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 09-10**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.18706	-1.190566	-1.189539	-1.188411	-1.190874	-1.193916
AR(1)	-1.19028	-1.205717	-1.20494	-1.203832	-1.204854	-1.203462
AR(2)	-1.189379	-1.204987	-1.204603	-1.205202	-1.206404	-1.199378
AR(3)	-1.187993	-1.203753	-1.205669	-1.208243	-1.262952	-1.204223
AR(4)	-1.188093	-1.20416	-1.206971	-1.262865	-1.206618	-1.20819
AR(5)	-1.189022	-1.202805	-1.205765	-1.245046	-1.208406	<b>-1.267819</b>

**Table 217: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 10-11**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.009292	-1.025687	-1.028507	-1.030183	-1.034909	-1.048699
AR(1)	-1.022426	-1.052627	-1.053294	-1.051907	-1.053131	-1.054444
AR(2)	-1.02575	-1.053282	-1.052327	-1.05501	-1.055436	-1.105836
AR(3)	-1.025408	-1.051928	-1.055677	-1.061047	-1.054387	<b>-1.130706</b>
AR(4)	-1.025443	-1.051701	-1.055928	-1.107349	-1.056239	-1.129321
AR(5)	-1.033402	-1.051581	-1.050234	-1.128314	-1.118099	-1.118149

**Table 218: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 11-12**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-0.863624	-0.883349	-0.889291	-0.896728	-0.899884	-0.924984
AR(1)	-0.882493	-0.915646	-0.915699	-0.914352	-0.913723	-0.924927
AR(2)	-0.882235	-0.915659	-0.913921	-0.90227	-0.914211	-1.016384
AR(3)	-0.883743	-0.914394	-0.91556	-0.923813	-0.979667	<b>-1.031993</b>
AR(4)	-0.882487	-0.91308	-0.914324	-1.015697	-1.020992	-1.030728
AR(5)	-0.897071	-0.913604	-1.0036	-1.028954	-1.027648	-1.029384

**Table 219: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 12-13**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-0.863624	-0.883349	-0.889291	-0.896728	-0.899884	-0.924984
AR(1)	-0.882493	-0.915646	-0.915699	-0.914352	-0.913723	-0.924927
AR(2)	-0.882235	-0.915659	-0.913921	-0.90227	-0.914211	-1.016384
AR(3)	-0.883743	-0.914394	-0.91556	-0.923813	-0.979667	<b>-1.031993</b>
AR(4)	-0.882487	-0.91308	-0.914324	-1.015697	-1.020992	-1.030728
AR(5)	-0.897071	-0.913604	-1.0036	-1.028954	-1.027648	-1.029384

**Table 220: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 13-14**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.837653	-0.855847	-0.856607	-0.866452	-0.869238	-0.888221
AR(1)	-0.853242	-0.886039	-0.888711	-0.887542	-0.886592	-0.888815
AR(2)	-0.854513	-0.853416	-0.885966	-0.890918	-0.889538	-0.968757
AR(3)	-0.854564	-0.887517	-0.891079	-0.893545	-0.959934	-0.983082
AR(4)	-0.853636	-0.886341	-0.889709	-0.95988	-0.963001	-0.984302
AR(5)	-0.86008	-0.885016	-0.885953	-0.98068	-0.980004	<b>-1.054096</b>

Table 221: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 14-15

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.765155	-0.791733	-0.806051	-0.811428	-0.821572	-0.82856
AR(1)	-0.782415	-0.828475	-0.83038	-0.833176	-0.821492	-0.837358
AR(2)	-0.79297	-0.82991	-0.83033	-0.839753	-0.838385	-0.935167
AR(3)	-0.795033	-0.830137	-0.84022	-0.831226	-0.839972	-0.836977
AR(4)	-0.796813	-0.828746	-0.838909	-0.939502	-0.928759	-0.844553
AR(5)	-0.805539	-0.827368	-0.834765	-0.853136	-0.844435	<b>-1.064611</b>

Table 222: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 15-16

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.746231	-0.771168	-0.773357	-0.782731	-0.788252	-0.8086
AR(1)	-0.76709	-0.828134	-0.835186	-0.831069	-0.831679	-0.834033
AR(2)	-0.768209	-0.835225	-0.832909	-0.84016	-0.853205	-0.942255
AR(3)	-0.772303	-0.834177	-0.83829	-0.95758	-0.857414	-0.958673
AR(4)	-0.772751	-0.832447	-0.837531	-0.894584	-0.949537	-0.958625
AR(5)	-0.78426	-0.831761	-0.910526	-0.97174	-0.971484	<b>-1.07643</b>

Table 223: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 16-17

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.746223	-0.76996	-0.778123	-0.777928	-0.812815	-0.838213
AR(1)	-0.769578	-0.815902	-0.81861	-0.8236	-0.821076	-0.836849
AR(2)	-0.768742	-0.822084	-0.824405	-0.786258	-0.819457	-0.869288
AR(3)	-0.769092	-0.818698	-0.824556	-0.799076	-0.830913	<b>-0.975089</b>
AR(4)	-0.772859	-0.817746	-0.824095	-0.94237	-0.849806	-0.846389
AR(5)	-0.781027	-0.818567	-0.833713	-0.966602	-0.850161	-0.867748

Table 224: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 17-18

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.688749	-0.760395	-0.759834	-0.749747	-0.821305	-0.830315
AR(1)	-0.755235	-0.892252	-0.873932	-0.794662	-0.88607	-0.81639
AR(2)	-0.757268	-0.896783	-0.888805	-0.880648	-0.769909	-0.886724
AR(3)	-0.754776	-0.779413	-0.810355	-0.892832	-0.766907	-1.012151
AR(4)	-0.749888	-0.77408	-0.893753	-0.877015	-0.964401	-0.908485
AR(5)	-0.728909	-0.765122	-0.951452	-0.996458	-0.922367	<b>-1.078687</b>

Table 225: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 18-19



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-0.86354	-0.915432	-0.925716	-0.929775	-0.942218	-0.953432
AR(1)	-0.902485	-0.94534	-0.952512	-0.952336	-0.950227	-0.952509
AR(2)	-0.915578	-0.950861	-0.953786	-0.955258	-0.953942	-1.023939
AR(3)	-0.916607	-0.952132	-0.955377	-1.028668	-1.026721	<b>-1.045051</b>
AR(4)	-0.917415	-0.95075	-0.954	-1.02643	-1.027889	-1.044228
AR(5)	-0.929926	-0.949367	-1.003673	-1.044341	-1.042581	-1.043301

Table 226: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 19-20

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-0.899604	-0.916804	-0.921059	-0.927999	-0.94012	-0.944318
AR(1)	-0.913714	-0.970982	-0.971799	-0.970432	-0.969862	-0.971073
AR(2)	-0.911132	-0.97172	-0.970217	-0.975897	-0.97497	-0.975977
AR(3)	-0.912877	-0.970357	-0.977458	-1.023424	<b>-1.053818</b>	-1.03283
AR(4)	-0.914475	-0.968975	-0.976518	-0.981268	-1.021837	-1.028325
AR(5)	-0.917149	-0.968067	-0.983233	-1.031815	-0.990765	-1.033412

Table 227: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 20-21

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.047042	-1.061323	-1.082026	-1.088849	-1.105015	-1.116393
AR(1)	-1.056591	-1.126333	-1.124999	-1.124782	-1.124955	-1.123599
AR(2)	-1.072632	-1.12497	-1.128107	-1.126814	-1.125734	-1.128013
AR(3)	-1.073033	-1.124725	-1.123892	<b>-1.174986</b>	-1.126449	-1.173195
AR(4)	-1.076587	-1.124775	-1.125785	-1.128456	-1.141678	-1.04109
AR(5)	-1.08564	-1.123683	-1.126923	-1.173081	-1.121784	-1.132901

Table 228: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 21-22

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.32171	-1.337974	-1.349589	-1.355057	-1.361901	-1.368371
AR(1)	-1.333887	-1.382465	-1.38153	-1.389628	-1.379559	-1.378389
AR(2)	-1.342655	-1.38149	-1.385193	-1.374896	-1.393731	-1.371845
AR(3)	-1.344294	-1.389544	-1.37302	-1.389426	<b>-1.409652</b>	-1.398506
AR(4)	-1.346011	-1.388449	-1.381821	-1.392371	-1.40241	-1.391271
AR(5)	-1.349256	-1.378544	-1.377171	-1.398462	-1.397095	-1.390317

Table 229: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 22-23

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR0	-1.40956	-1.414592	-1.414962	-1.418927	-1.418952	-1.431698
AR(1)	-1.413894	-1.435218	-1.477008	-1.471331	-1.475427	-1.473752
AR(2)	-1.413605	-1.478255	-1.474535	-1.471653	-1.473975	-1.472139
AR(3)	-1.415231	-1.476938	-1.475415	-1.47934	-1.483591	-1.47215
AR(4)	-1.413989	-1.475952	-1.478806	-1.477508	-1.471212	-1.482024
AR(5)	-1.418697	-1.475467	-1.447872	<b>-1.487143</b>	-1.486291	-1.476727

Table 230: AIC values for ARMA parameters in Equation 6 (Model IIIA) for Hour 23-24

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.245198	-1.246557	-1.248704	-1.253079	-1.260406	-1.267504
AR(1)	-1.246242	-1.283968	-1.282979	-1.281892	-1.281215	-1.27991
AR(2)	-1.247117	-1.282992	-1.282522	-1.281156	-1.280997	-1.279641
AR(3)	-1.247973	-1.281942	-1.281157	-1.281699	-1.279681	-1.288258
AR(4)	-1.251154	-1.281129	-1.281154	<b>-1.306236</b>	-1.290285	-1.288941
AR(5)	-1.255113	-1.279794	-1.280397	-1.284044	-1.282811	-1.296683

Table 231: Results of Model-III A -Equation 6 and Equation 7

Hours	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_9$	$\beta_{10}$	$\beta_{11}$	$\beta_{12}$
00-01	-0.0001 (0.8723)	(4,3)		0.0014 (0.3421)	<b>0.0026</b> (0.0000)	<b>0.3068</b> (0.0000)	<b>0.5821</b> (0.0000)
		<b>-0.0888</b> (0.003)	<b>-0.9622</b> (0.0000)				
01-02	<b>0.0007</b> (0.0432)	(2,5)		<b>-0.0012</b> (0.0196)	<b>0.0016</b> (0.0000)	<b>0.247</b> (0.0000)	<b>0.6781</b> (0.0000)
		<b>-0.5148</b> (0.0000)	<b>0.098</b> (0.0028)				
02-03	0.0002 (0.328)	(4,5)		-0.0007 (0.1054)	<b>0.002</b> (0.0000)	<b>0.2265</b> (0.0000)	<b>0.6554</b> (0.0000)
		<b>0.6338</b> (0.0000)	<b>0.0501</b> (0.0000)				
03-04	0.0003 (0.1241)	(3,5)		<b>-0.0008</b> (0.0319)	<b>0.0033</b> (0.0000)	<b>0.2639</b> (0.0000)	<b>0.5283</b> (0.0000)
		<b>0.9174</b> (0.0000)	0.0338 (0.3092)				
04-05	-0.0014 (0.3585)	(3,4)		0.0027 (0.2032)	<b>0.0038</b> (0.0000)	<b>0.2819</b> (0.0000)	<b>0.4947</b> (0.0000)
		<b>0.8313</b> (0.0000)	-0.0507 (0.1576)				
05-06	0.0001 (0.4673)	(5,4)		-0.0005 (0.0931)	<b>0.0017</b> (0.0000)	<b>0.2049</b> (0.0000)	<b>0.6931</b> (0.0000)
		<b>0.0911</b> (0.003)	<b>-0.4755</b> (0.0000)				
06-07	-0.0004 (0.7014)	(5,3)		0.0008 (0.6238)	<b>0.002</b> (0.0000)	<b>0.2564</b> (0.0000)	<b>0.6145</b> (0.0000)
		-0.0377 (0.257)	<b>-0.9474</b> (0.0000)				
07-08	-0.0007 (0.4708)	(3,3)		0.0007 (0.6631)	<b>0.0012</b> (0.0000)	<b>0.1257</b> (0.0000)	<b>0.7915</b> (0.0000)
		<b>0.8541</b> (0.0000)	<b>-0.9332</b> (0.0000)				
08-09	-0.0015 (0.2779)	(3,5)		0.001 (0.6007)	<b>0.0023</b> (0.0000)	<b>0.2433</b> (0.0000)	<b>0.63</b> (0.0000)
		<b>0.8124</b> (0.0000)	-0.0596 (0.0759)				
09-10	3.67E-05 (0.9846)	(5,5)		5.66E-05 (0.9838)	<b>0.0061</b> (0.0000)	<b>0.2861</b> (0.0000)	<b>0.3941</b> (0.0000)
		<b>0.8438</b> (0.0000)	<b>-0.907</b> (0.0000)				
10-11	-0.0003 (0.8368)	(3,5)		0.0015 (0.495)	<b>0.0081</b> (0.0000)	<b>0.3614</b> (0.0000)	<b>0.2945</b> (0.0000)
		<b>0.7771</b> (0.0000)	<b>-0.1529</b> (0.0000)				
11-12	-0.0024 (0.2024)	(3,5)		0.0029 (0.247)	<b>0.0034</b> (0.0000)	<b>0.2105</b> (0.0000)	<b>0.6613</b> (0.0000)
		<b>0.6026</b> (0.0000)	<b>-0.202</b> (0.0000)				
12-13	-0.0017	(5,5)		0.0026	<b>0.0034</b>	<b>0.2687</b>	<b>0.6164</b>

Hours	Mean Equation				Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_9$	$\beta_{10}$	$\beta_{11}$	$\beta_{12}$	
	(0.2235)	<b>0.804</b> (0.0000)	<b>-0.8633</b> (0.0000)	(0.2277)	<b>(0.0000)</b>	<b>(0.0000)</b>	<b>(0.0000)</b>	
13-14	-0.0022 (0.052)	(5,5)		0.0031 (0.0646)	<b>0.0034</b> (0.0000)	<b>0.2523</b> (0.0000)	<b>0.6303</b> (0.0000)	
		<b>0.8175</b> (0.0000)	<b>-0.8694</b> (0.0000)					
14-15	-0.0015 (0.2325)	(5,5)		0.0031 (0.1245)	<b>0.0033</b> (0.0000)	<b>0.369</b> (0.0000)	<b>0.5628</b> (0.0000)	
		<b>0.8318</b> (0.0000)	<b>-0.897</b> (0.0000)					
15-16	<b>0.0005</b> (0.0028)	(5,5)		<b>-0.001</b> (0.0000)	<b>0.0032</b> (0.0000)	<b>0.3032</b> (0.0000)	<b>0.5932</b> (0.0000)	
		<b>0.8903</b> (0.0000)	<b>-0.9032</b> (0.0000)					
16-17	<b>-0.0044</b> (0.0053)	(3,5)		0.0041 (0.0682)	<b>0.0017</b> (0.0000)	<b>0.2348</b> (0.0000)	<b>0.734</b> (0.0000)	
		<b>0.5289</b> (0.0000)	<b>-0.2643</b> (0.0000)					
17-18	-0.0027 (0.0563)	(5,5)		0.0021 (0.3413)	<b>0.0008</b> (0.0000)	<b>0.1392</b> (0.0000)	<b>0.8433</b> (0.0000)	
		<b>0.6464</b> (0.0000)	<b>-0.8221</b> (0.0000)					
18-19	-0.0016 (0.1732)	(3,5)		0.0009 (0.5677)	<b>0.0015</b> (0.0000)	<b>0.2047</b> (0.0000)	<b>0.7489</b> (0.0000)	
		<b>0.7389</b> (0.0000)	<b>-0.1487</b> (0.0000)					
19-20	-0.0001 (0.2552)	(3,4)		-0.0002 (0.2422)	<b>0.0073</b> (0.0000)	<b>0.573</b> (0.0000)	<b>0.2363</b> (0.0000)	
		<b>0.8597</b> (0.0000)	-0.0034 (0.9061)					
20-21	<b>-0.0013</b> (0.075)	(3,3)		0.0008 (0.3954)	<b>0.001</b> (0.0000)	<b>0.1525</b> (0.0000)	<b>0.8088</b> (0.0000)	
		<b>0.7654</b> (0.0000)	<b>-0.946</b> (0.0000)					
21-22	-0.0007 (0.4543)	(3,4)		0.001 (0.3968)	<b>0.0006</b> (0.0000)	<b>0.1529</b> (0.0000)	<b>0.8251</b> (0.0000)	
		<b>0.7546</b> (0.0000)	-0.0428 (0.2418)					
22-23	-0.0004 (0.5873)	(5,3)		<b>-0.3229</b> (0.013)	<b>0.0011</b> (0.0000)	<b>0.4432</b> (0.0000)	<b>0.5848</b> (0.0000)	
		-0.0031 (0.9167)	<b>-0.9332</b> (0.0000)					
23-24	-0.0011 (0.3096)	(4,3)		0.0022 (0.1758)	<b>0.0022</b> (0.0000)	<b>0.2566</b> (0.0000)	<b>0.6419</b> (0.0000)	
		-0.0565 (0.0608)	<b>-0.9446</b> (0.0000)					

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

From Table 231, it is observed from the mean equation (Equation 6) that the coefficients of the dummy variable (which takes the value of 0 for the period from 1 April 2010 to 31 March 2012 and value of 1 for the period from 1 April 2012 to 31 March 2014) is found to be significant only

for four hours (01-02, 03-04, 15-16, 22-23) out of the twenty four hours, indicating that the introduction of fifteen minute contracts does not affect the current return in case of twenty hours.

In the variance equation (Equation 7), ARCH effects ( $\beta_{12}$ ) and GARCH effects ( $\beta_{13}$ ) in the variance equation are found to be significant for all the twenty four hours.

### Model IIIB

In Model IIIB,  $D_t^*$ , the dummy variable in the variance equation shows the impact of introduction of fifteen minute electricity day ahead contracts on the return volatility. The AIC values for ARMA parameters in mean equation (Equation 8 of Model IIIB) are reported for hours in Table 232 to Table 255. Table 256 reports the results of the estimation.

**Table 232: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 00-01**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.292712	-1.291339	-1.291892	-1.29301	-1.303152	-1.307952
AR(1)	-1.291338	-1.291861	-1.325507	-1.323817	-1.323709	-1.321222
AR(2)	-1.291504	-1.325542	-1.324018	-1.320387	-1.323594	-1.322281
AR(3)	-1.291225	-1.324191	-1.321069	-1.328805	-1.329068	-1.319437
AR(4)	-1.296796	-1.323204	-1.323663	-1.323054	-1.328964	-1.319431
AR(5)	-1.299388	-1.323815	-1.322281	-1.32564	-1.327614	<b>-1.331075</b>

**Table 233: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 01-02**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.362815	-1.361429	-1.360488	-1.360813	-1.376733	-1.380234
AR(1)	-1.361429	-1.36162	-1.360755	-1.391553	-1.390838	-1.395067
AR(2)	-1.360339	-1.360792	-1.391149	-1.390212	-1.368714	-1.396686
AR(3)	-1.359853	-1.391424	-1.388643	-1.395865	-1.388257	-1.391076
AR(4)	-1.370879	-1.389619	-1.38813	-1.382121	<b>-1.397979</b>	-1.386699
AR(5)	-1.372769	-1.395	-1.396912	-1.389765	-1.384567	-1.386397

**Table 234: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 02-03**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.44789	-1.446652	-1.447485	-1.448241	-1.460734	-1.463614
AR(1)	-1.446635	-1.449011	-1.448287	-1.486335	-1.484945	-1.487732
AR(2)	-1.446866	-1.448232	-1.490797	-1.484505	-1.488103	-1.486996
AR(3)	-1.446422	-1.486333	-1.46648	-1.483523	-1.481838	-1.480845
AR(4)	-1.453243	-1.484963	-1.488048	-1.486166	<b>-1.491453</b>	-1.478652
AR(5)	-1.455433	-1.487283	-1.485495	-1.487864	-1.483526	-1.478982

**Table 235: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 03-04**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.449137	-1.447872	-1.450169	-1.45415	-1.461027	-1.461948
AR(1)	-1.447842	-1.478617	-1.478659	-1.477252	-1.476051	<b>-1.479628</b>
AR(2)	-1.449007	-1.478926	-1.478423	-1.477244	-1.464118	-1.47693
AR(3)	-1.451137	-1.477519	-1.477323	-1.476034	-1.475262	-1.465156
AR(4)	-1.454614	-1.476252	-1.479337	-1.477009	-1.478673	-1.472085
AR(5)	-1.454434	-1.479212	-1.479246	-1.456	-1.456221	-1.468179

**Table 236: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 04-05**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.373086	-1.372641	-1.377647	-1.38425	-1.387801	-1.388049
AR(1)	-1.372449	<b>-1.4048</b>	-1.401211	-1.403311	-1.404777	-1.404295
AR(2)	-1.375656	-1.403407	-1.403758	-1.389384	-1.400791	-1.395609
AR(3)	-1.379808	-1.403183	-1.3989	-1.397479	-1.404655	-1.401113
AR(4)	-1.381504	-1.404008	-1.397794	-1.40398	-1.390735	-1.401289
AR(5)	-1.382213	-1.403303	-1.401748	-1.403692	-1.400976	-1.395656

**Table 237: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 05-06**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.414229	-1.415447	-1.4144	-1.414171	-1.436921	-1.441309
AR(1)	-1.415356	-1.462845	-1.461523	-1.461012	-1.460578	-1.465786
AR(2)	-1.414207	-1.461535	-1.4635	-1.462834	-1.465186	-1.46413
AR(3)	-1.413068	-1.46078	-1.463016	-1.45538	-1.464223	-1.46291
AR(4)	-1.428571	-1.460056	-1.464849	-1.462688	-1.464816	<b>-1.467426</b>
AR(5)	-1.431252	-1.466299	-1.46381	-1.46261	-1.466527	-1.464196

**Table 238: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 06-07**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.524379	-1.52432	-1.523076	-1.526368	-1.530113	-1.535783
AR(1)	-1.524265	-1.523436	-1.544294	-1.547548	-1.546148	-1.544927
AR(2)	-1.523207	-1.547948	-1.54699	-1.546136	-1.546818	-1.545669
AR(3)	-1.525382	-1.547375	-1.538462	-1.561929	-1.547617	-1.549238
AR(4)	-1.528707	-1.546129	-1.546445	-1.547592	-1.561558	-1.537774
AR(5)	-1.53226	-1.545649	-1.546173	<b>-1.563655</b>	-1.563539	-1.562418

**Table 239: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 07-08**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.456559	-1.455686	-1.460335	-1.467339	-1.46935	-1.473013
AR(1)	-1.455593	-1.459179	-1.490334	-1.488963	-1.487715	-1.486349
AR(2)	-1.460025	-1.490146	-1.488953	-1.489608	-1.489078	-1.470379
AR(3)	-1.462489	-1.489008	-1.489563	-1.519184	-1.520613	<b>-1.521108</b>
AR(4)	-1.463256	-1.487648	-1.48896	-1.494422	-1.505466	-1.500583
AR(5)	-1.467317	-1.486274	-1.488838	-1.520806	-1.500502	-1.499181

**Table 240: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 08-09**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.3817	-1.380515	-1.383264	-1.383938	-1.385689	-1.398275
AR(1)	-1.380483	-1.381708	-1.40156	-1.400223	-1.400087	-1.400025
AR(2)	-1.382651	-1.40149	-1.403699	-1.402341	-1.401352	-1.418803
AR(3)	-1.381779	-1.381769	-1.402334	-1.409181	-1.426292	-1.435608
AR(4)	-1.382112	-1.399693	-1.40132	-1.399351	-1.407095	-1.434258
AR(5)	-1.39344	-1.3984	-1.41747	-1.43531	-1.434074	<b>-1.437926</b>

**Table 241: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 09-10**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.191534	-1.195218	-1.194192	-1.193009	-1.195099	-1.198237
AR(1)	-1.194917	-1.209894	-1.195245	-1.208056	-1.209202	-1.207844
AR(2)	-1.194039	-1.20923	-1.208646	-1.209314	-1.198387	-1.209062
AR(3)	-1.192649	-1.204337	-1.209781	-1.245498	-1.186846	-1.249881
AR(4)	-1.19251	-1.208462	-1.210922	<b>-1.265121</b>	-1.210751	-1.212192
AR(5)	-1.193327	-1.20719	-1.209673	-1.21851	-1.209363	-1.198862

**Table 242: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 10-11**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.011126	-1.026945	-1.029716	-1.031096	-1.035672	-1.049514
AR(1)	-1.02378	-1.053251	-1.053764	-1.052374	-1.053845	-1.055163
AR(2)	-1.027159	-1.053747	-1.053075	-1.055715	-1.056135	-1.110182
AR(3)	-1.026692	-1.050056	-1.05638	-1.119701	-1.060128	<b>-1.13349</b>
AR(4)	-1.026577	-1.048669	-1.056608	-1.107978	-1.11258	-1.118785
AR(5)	-1.034349	-1.052303	-1.099841	-1.130963	-1.120351	-1.121071

**Table 243: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 11-12**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.864013	-0.883495	-0.889185	-0.896623	-0.899789	-0.924678
AR(1)	-0.883168	-0.915412	-0.915401	-0.914051	-0.913474	-0.924603
AR(2)	-0.882357	-0.915365	-0.913707	-0.915137	-0.913938	-1.016481
AR(3)	-0.883724	-0.914094	-0.890896	-0.980177	-0.979234	<b>-1.031404</b>
AR(4)	-0.882446	-0.912788	-0.914051	-0.912789	-1.008786	-1.03012
AR(5)	-0.89696	-0.909416	-1.005016	-1.028331	-1.027024	-1.028782

**Table 244: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 12-13**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.821395	-0.845909	-0.847018	-0.856048	-0.860392	-0.882644
AR(1)	-0.841169	-0.875798	-0.877189	-0.875955	-0.874575	-0.882154
AR(2)	-0.837551	-0.877057	-0.876588	-0.878607	-0.877261	-0.961524
AR(3)	-0.839857	-0.876066	-0.878583	-0.881487	-0.867165	-0.976614
AR(4)	-0.839043	-0.866118	-0.877296	-0.876298	-0.889106	-0.903427
AR(5)	-0.851922	-0.873854	-0.946359	-0.97419	-0.973152	<b>-1.062352</b>

**Table 245: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 13-14**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.838142	-0.856528	-0.85676	-0.866638	-0.86941	-0.887744
AR(1)	-0.853854	-0.885725	-0.888158	-0.886982	-0.885998	-0.884609
AR(2)	-0.855292	-0.887977	-0.885652	-0.889403	-0.888995	-0.969432
AR(3)	-0.855162	-0.886967	-0.890545	-0.960223	-0.876458	-0.898948
AR(4)	-0.85417	-0.885777	-0.889183	-0.959117	-0.894654	-0.983927
AR(5)	-0.860119	-0.884451	-0.885865	-0.980281	-0.9796	<b>-1.053264</b>

**Table 246: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 14-15**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.770708	-0.793347	-0.80898	-0.813781	-0.823507	-0.829175
AR(1)	-0.786811	-0.822995	-0.831729	-0.831673	-0.828919	-0.831323
AR(2)	-0.796975	-0.831273	-0.835193	-0.841263	-0.839904	-0.936827
AR(3)	-0.798871	-0.831587	-0.841744	-0.930264	-0.943884	<b>-0.947193</b>
AR(4)	-0.800161	-0.830197	-0.840457	-0.942604	-0.846289	-0.845416
AR(5)	-0.807774	-0.828814	-0.836691	-0.839665	-0.940935	-0.855403

**Table 247: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 15-16**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.77095	-0.794284	-0.796463	-0.802244	-0.798198	-0.823837
AR(1)	-0.790022	-0.83084	-0.838047	-0.836679	-0.836633	-0.828155
AR(2)	-0.792108	-0.839079	-0.835193	-0.840294	-0.839466	-0.945633
AR(3)	-0.794486	-0.837791	-0.832405	-0.84768	-0.86147	-0.960536
AR(4)	-0.794415	-0.837205	-0.765867	-0.932002	-0.925156	-0.960843
AR(5)	-0.803973	-0.835707	-0.919483	-0.969505	-0.919011	<b>-0.981205</b>

**Table 248: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 16-17**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.770173	-0.7934	-0.800551	-0.808499	-0.829208	-0.849253
AR(1)	-0.785279	-0.825107	-0.849592	-0.84138	-0.837894	-0.847879
AR(2)	-0.791113	-0.844596	-0.848336	-0.836296	-0.847125	-0.960723
AR(3)	-0.791814	-0.843777	-0.827793	-0.94235	-0.94816	-0.854072
AR(4)	-0.793919	-0.825689	-0.805529	-0.860905	-0.881432	-0.930122
AR(5)	-0.806398	-0.825092	-0.850845	-0.930886	-0.860268	<b>-0.977778</b>

**Table 249: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 17-18**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.779148	-0.808113	-0.810608	-0.820542	-0.833097	-0.843748
AR(1)	-0.802503	-0.823186	-0.84315	-0.858125	-0.834362	-0.827732
AR(2)	-0.806073	-0.824508	-0.844928	-0.95461	-0.866281	-1.001898
AR(3)	-0.800891	-0.921634	-0.916166	-0.948286	-0.894001	-1.019276
AR(4)	-0.814421	-0.894298	-0.830295	-0.894957	-0.97218	-0.973296
AR(5)	-0.833306	-0.822813	-0.920331	-0.725103	-0.954475	<b>-1.036767</b>

**Table 250: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 18-19**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.866797	-0.917671	-0.927894	-0.931538	-0.943944	-0.954511
AR(1)	-0.905	-0.947116	-0.953456	-0.953315	-0.951946	-0.953669
AR(2)	-0.91811	-0.95201	-0.956308	-0.956489	-0.955201	-1.025746
AR(3)	-0.918921	-0.953164	-0.956712	-1.030373	-1.027037	<b>-1.04625</b>
AR(4)	-0.919618	-0.95179	-0.955328	-1.026932	-1.044149	-0.98389
AR(5)	-0.93128	-0.950406	-1.006285	-1.045144	-0.991292	-0.981755

**Table 251: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 19-20**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-0.915902	-0.929129	-0.933183	-0.940657	-0.954148	-0.95714
AR(1)	-0.926718	-0.978868	-0.978739	-0.969779	-0.97045	-0.975181
AR(2)	-0.923189	-0.978682	-0.979423	-0.983898	-0.983163	-1.024662
AR(3)	-0.924893	-0.977318	-0.961646	-1.032029	-1.056532	-0.994981
AR(4)	-0.92664	-0.975943	-0.984808	-1.056504	<b>-1.064159</b>	-0.998205
AR(5)	-0.92855	-0.975322	-0.969581	-0.985614	-0.998345	-0.996396

**Table 252: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 20-21**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.067819	-1.076652	-1.090746	-1.098242	-1.115841	-1.126533
AR(1)	-1.07386	-1.13758	-1.136202	-1.135414	-1.135569	-1.13423
AR(2)	-1.082222	-1.136195	-1.138069	-1.13673	-1.135044	-1.133748
AR(3)	-1.082338	-1.135253	-1.136736	-1.182592	-1.136149	-1.11401
AR(4)	-1.086038	-1.135299	-1.120662	-1.139034	-1.140659	-1.137133
AR(5)	-1.094129	-1.134133	-1.109185	-1.181214	-1.184021	<b>-1.188974</b>

**Table 253: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 21-22**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.345064	-1.359457	-1.367753	-1.373823	-1.380172	-1.387093
AR(1)	-1.356172	-1.401382	-1.400115	-1.403745	-1.403587	-1.396822
AR(2)	-1.361789	-1.381746	-1.412731	-1.406837	-1.400368	-1.395482
AR(3)	-1.363559	-1.403712	-1.402328	-1.407329	-1.435613	-1.414643
AR(4)	-1.365191	-1.39773	-1.400689	-1.427637	-1.41795	-1.413335
AR(5)	-1.369031	-1.396946	-1.395627	-1.414619	-1.414244	<b>-1.445117</b>

**Table 254: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 22-23**

AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.439073	-1.44262	-1.442399	-1.445812	-1.444734	-1.458475
AR(1)	-1.442162	-1.502075	-1.501378	-1.497493	-1.490383	-1.472627
AR(2)	-1.441435	-1.501401	-1.500534	-1.505002	-1.484628	-1.494439
AR(3)	-1.443013	-1.500112	-1.499179	-1.502457	<b>-1.512631</b>	-1.5058
AR(4)	-1.441634	-1.499149	-1.495425	-1.49371	-1.494565	-1.505764
AR(5)	-1.448008	-1.47196	-1.464039	-1.50784	-1.501389	-1.503275

**Table 255: AIC values for ARMA parameters in Equation 8 (Model-IIIB) for Hour 23-24**



AIC Values	MA(0)	MA(1)	MA(2)	MA(3)	MA(4)	MA(5)
AR(0)	-1.257298	-1.258374	-1.259861	-1.263654	-1.269957	-1.277239
AR(1)	-1.258117	-1.292948	-1.291914	-1.290921	-1.290222	-1.288978
AR(2)	-1.258604	-1.291926	-1.29111	-1.291057	-1.289547	-1.287625
AR(3)	-1.259326	-1.290978	-1.289771	-1.298594	-1.288289	-1.309121
AR(4)	-1.261906	-1.290163	-1.289702	-1.288326	<b>-1.312402</b>	-1.296296
AR(5)	-1.265909	-1.288868	-1.299425	-1.296552	-1.299471	-1.306803

Table 256: Results of Model IIIB –Equation 8 and Equation 9

	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_{13}$	$\beta_{14}$	$\beta_{15}$	$\beta_{16}$
00-01	0.0002 (0.4216)	(5,5)		<b>0.0033</b> (0.0000)	<b>0.238</b> (0.0000)	<b>0.6501</b> (0.0000)	<b>-0.0017</b> (0.0000)
		<b>0.8564</b> (0.0000)	<b>-0.9574</b> (0.0000)				
01-02	0.0001 (0.8965)	(4,4)		<b>0.0024</b> (0.0000)	<b>0.2328</b> (0.0000)	<b>0.6877</b> (0.0000)	<b>-0.0013</b> (0.0000)
		<b>-0.3722</b> (0.0000)	<b>0.338</b> (0.0000)				
02-03	<b>-0.0002</b> (0.0395)	(4,4)		<b>0.0027</b> (0.0000)	<b>0.2316</b> (0.0000)	<b>0.6471</b> (0.0000)	<b>-0.0011</b> (0.0000)
		<b>0.7432</b> (0.0000)	<b>-0.8594</b> (0.0000)				
03-04	-0.0001 (0.6624)	(3,5)		<b>0.004</b> (0.0000)	<b>0.2417</b> (0.0000)	<b>0.5538</b> (0.0000)	<b>-0.0014</b> (0.0000)
		<b>0.9503</b> (0.0000)	<b>0.051</b> (0.041)				
04-05	-9.83E-05 (0.4042)	(1,1)		<b>0.0033</b> (0.0000)	<b>0.2159</b> (0.0000)	<b>0.6322</b> (0.0000)	<b>-0.0013</b> (0.0000)
		<b>0.93</b> (0.0000)	<b>-0.9981</b> (0.0000)				
05-06	-0.0001 (0.5302)	(4,5)		<b>0.0022</b> (0.0000)	<b>0.2032</b> (0.0000)	<b>0.6937</b> (0.0000)	<b>-0.0008</b> (0.0000)
		<b>0.363</b> (0.0000)	<b>0.1311</b> (0.0000)				
06-07	0.0002 (0.8004)	(5,3)		<b>0.0025</b> (0.0000)	<b>0.2532</b> (0.0000)	<b>0.5966</b> (0.0000)	<b>-0.0004</b> (0.0434)
		-0.0548 (0.0916)	<b>-0.949</b> (0.0000)				
07-08	-0.0002 (0.8017)	(3,5)		<b>0.0019</b> (0.0000)	<b>0.1485</b> (0.0000)	<b>0.766</b> (0.0000)	<b>-0.001</b> (0.0000)
		<b>0.8045</b> (0.0000)	-0.0589 (0.0713)				
08-09	-0.0003 (0.7064)	(5,5)		<b>0.0048</b> (0.0000)	<b>0.3397</b> (0.0000)	<b>0.456</b> (0.0000)	<b>-0.0017</b> (0.0000)
		<b>0.5262</b> (0.0000)	<b>-0.623</b> (0.0000)				
09-10	-0.0001 (0.9213)	(4,3)		<b>0.0071</b> (0.0000)	<b>0.2906</b> (0.0000)	<b>0.3747</b> (0.0000)	<b>-0.0012</b> (0.0065)
		-0.0276 (0.3875)	<b>-0.9066</b> (0.0000)				
10-11	0.0005 (0.626)	(3,5)		<b>0.0092</b> (0.0000)	<b>0.3482</b> (0.0000)	<b>0.2976</b> (0.0000)	<b>-0.0018</b> (0.0002)
		<b>0.7676</b> (0.0000)	<b>-0.1553</b> (0.0000)				
11-12	-0.0008 (0.5697)	(3,5)		<b>0.0035</b> (0.0000)	<b>0.2076</b> (0.0000)	<b>0.6655</b> (0.0000)	-0.0002 (0.2006)
		<b>0.6016</b> (0.0000)	<b>-0.2016</b> (0.0000)				
12-13	-0.0003	(5,5)		<b>0.0038</b>	<b>0.2682</b>	<b>0.6166</b>	<b>-0.0005</b>

	Mean Equation			Variance Equation			
	$\mu_1$	$\delta_i$	$\delta_j$	$\beta_{13}$	$\beta_{14}$	$\beta_{15}$	$\beta_{16}$
	(0.7386)	<b>0.8025</b> (0.0000)	<b>-0.862</b> (0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0174)
13-14	-0.0005 (0.5605)	(5,5)		<b>0.0037</b> (0.0000)	<b>0.2421</b> (0.0000)	<b>0.6393</b> (0.0000)	<b>-0.0007</b> (0.0033)
		<b>0.8145</b> (0.0000)	<b>-0.8675</b> (0.0000)				
14-15	-0.0004 (0.7695)	(3,5)		<b>0.0038</b> (0.0000)	<b>0.2441</b> (0.0000)	<b>0.6547</b> (0.0000)	<b>-0.0008</b> (0.0015)
		<b>0.6013</b> (0.0000)	<b>-0.1922</b> (0.0000)				
15-16	-0.0002 (0.4515)	(5,5)		<b>0.0046</b> (0.0000)	<b>0.3394</b> (0.0000)	<b>0.5614</b> (0.0000)	<b>-0.0011</b> (0.002)
		<b>0.7571</b> (0.0000)	<b>-0.7561</b> (0.0000)				
16-17	-0.0018 (0.1281)	(5,5)		<b>0.0027</b> (0.0000)	<b>0.2216</b> (0.0000)	<b>0.7273</b> (0.0000)	<b>-0.0012</b> (0.0000)
		0.004 (0.9683)	<b>-0.262</b> (0.0059)				
17-18	-0.001 (0.3065)	(5,5)		<b>0.0016</b> (0.0000)	<b>0.2137</b> (0.0000)	<b>0.7608</b> (0.0000)	<b>-0.0006</b> (0.0012)
		<b>0.6577</b> (0.0000)	<b>-0.8692</b> (0.0000)				
18-19	-0.0011 (0.2329)	(3,5)		<b>0.0018</b> (0.0000)	<b>0.1984</b> (0.0000)	<b>0.7534</b> (0.0000)	-0.0004 (0.0221)
		<b>0.7189</b> (0.0000)	<b>-0.1487</b> (0.0000)				
19-20	-1.55E-05 (0.9501)	(4,4)		<b>0.0099</b> (0.0000)	<b>0.4974</b> (0.0000)	<b>0.2385</b> (0.0000)	<b>-0.0029</b> (0.0000)
		<b>-0.6709</b> (0.0000)	<b>0.8138</b> (0.0000)				
20-21	-0.0002 (0.1202)	(5,5)		<b>0.002</b> (0.0000)	<b>0.1697</b> (0.0000)	<b>0.769</b> (0.0000)	<b>-0.0008</b> (0.0004)
		<b>-0.6651</b> (0.0000)	<b>0.8625</b> (0.0000)				
21-22	0.0002 (0.61)	(5,5)		<b>0.0016</b> (0.0000)	<b>0.1853</b> (0.0000)	<b>0.7626</b> (0.0000)	<b>-0.0009</b> (0.0000)
		<b>0.7847</b> (0.0000)	<b>-0.883</b> (0.0000)				
22-23	-0.0001 (0.3569)	(3,4)		<b>0.0023</b> (0.0000)	<b>0.4582</b> (0.0000)	<b>0.553</b> (0.0000)	<b>-0.0015</b> (0.0000)
		<b>0.7283</b> (0.0000)	<b>0.0433</b> (0.0000)				
23-24	0.0004 (0.6945)	(4,4)		<b>0.0024</b> (0.0000)	<b>0.2356</b> (0.0000)	<b>0.68</b> (0.0000)	<b>-0.001</b> (0.0000)
		<b>-0.6954</b> (0.0000)	<b>0.7273</b> (0.0000)				

p value is indicated in parenthesis; coefficients marked in bold are significant at 5% significance level

From Table 256, it is observed from the variance equation (Equation 9), ARCH and GARCH effects ( $\beta_{16}$  and  $\beta_{17}$ ) are found to be significant for all the twenty four hours. The most remarkable result is that of the significance of introduction of fifteen minute contracts on return volatility, it is found that the dummy variable ( $\beta_{16}$ ) is negative and significant for twenty two

hours out of twenty four hours. This shows that introduction of fifteen minute contracts has reduced the return volatility. The dummy variable is found to be significant in two hours (11-12 and 18-19).

## **5 Concluding Remarks**

Given the thrust on the deregulation of electricity markets in India since 2003, the short term electricity market with power exchanges in particular have evolved rapidly to support the growth of the power markets in an efficient manner. Since their year of inception 2008, power exchanges are now more efficient and are able to mitigate risks arising from price volatility for the participants to a large extent. The two power exchanges Indian Energy Exchange (IEX) and Power Exchange of India Limited (PXIL) have aided in better utilisation of electricity generated in the country and have taken care of unmet demand for power. Volumes on the power exchange have grown almost 14 times. But the short term market in India is yet to achieve its full potential. In 2013-14, the two power exchanges witnessed constraints on the volume of electricity due to congestion in transmission. During the year 2013-14, the actual transacted volume on power exchanges was 30029.62 MU whereas unconstrained volume was 35621.04MU, leading to a gap of 5591.42 MU amounting to 16% as a percentage of the unconstrained volume.

In light of the evolving nature of the Indian power sector, power exchanges are expected to play a critical role in the process. Power exchanges are expected to play the role of not only taking care of intermediate load requirements but that of providing price signals and a platform for risk mitigation. Currently, only 3% of the total electricity generated is traded via power exchange based electricity markets in order to increase the trading it is necessary to allocate scarce transmission resources and a need for depth in trading in the power exchange market.

In this study, we estimate six variants of a combination of ARMA GARCH model to assess the impact of weekday effect on current return of hours and return volatility respectively; the impact of volume on return volatility for the W2 bid area (highest volume among 12 bid areas of IEX). We also examine the impact of introduction of fifteen minute contracts (fifteen minute contracts were introduced on 1 April 2012) on current return and return volatility for the same bid area. We calibrate hourly models on returns consisting of data from 1 April 2010 to 31 March 2014. For estimating four out of the six variants of the model we calibrate the hourly models separately

for two sets of periods (first period – 1 April 2010 to 31 March 2012 and second period – 1 April 2012 to 31 March 2014). In the remaining two variants of the model we calibrate the hourly models for the consolidated period (1 April 2010 to 31 March 2014). The results indicate that most of the hours exhibit weekday effect on mean returns. The effect of higher prices on weekdays is evident from the impact of weekday effect on return volatility. Another, conclusion that is derived from the model estimation is the significant volume effect on the return volatility of peak hours. On studying the impact of introduction of fifteen minute day ahead electricity contracts it is found that there is no effect on the current return while a significant impact is on the return volatility twenty two hours out of twenty four hours. The return volatility has declined with the introduction of contracts with shorter blocks (provision of fifteen minute blocks) in the day ahead electricity market.

Based on the empirical analysis it can be concluded that an increase in the depth of the market is possible by introducing electricity contracts with shorter blocks – five minute contracts on power exchanges and thereby, increasing the level of participation by players. For participants, willing to sell or purchase longer contracts (longer than five minute contracts), a provision of blocking several five minute contracts at a stretch would be available (referred to as block orders). Five minute contracts are offered by Australia Energy Market Operator (AEMO), six five minute dispatch prices are averaged in order to determine half hourly average price. Besides this, an expansion of product portfolio on power exchanges would increase the liquidity in the market and ensure transparency in the discovery of price. As of now, the two power exchanges provide only physical delivery linked products, in time to come, they could consider providing hedging instruments in order to square of their positions as available in the commodity exchanges. This will act as a safe guard for the buyer in case of non-delivery of electricity. Such products have been introduced in developed power exchanges including Nord Pool, where financial products were introduced in the year 1995, there is no provision for physical delivery of financial market power contracts.

Thus to conclude one can say power exchanges are playing a significant role in the electricity market, but it has become imperative to deepen the short term electricity markets in order to increase the efficiency. The results of the current study can be seen as one of the starting points for further empirical work on the Indian day ahead electricity market.

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