BIFEC

Hedging Strategy for Electricity Market Price Volatility:

*The Case of Turkish Electricity Market*

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The aim of work

• In this work, Petrol Future Contracts are analyzed to forecast whether these contracts could be used as hedging instruments against the volatility of Turkish electricity market prices.

• Volatility in the Turkish electricity market prices are quantified and the optimal hedging ratio is estimated by using relevant econometric methods and approaches.

• Based on our empirical findings, recommendations are made for the market participants to assist them for hedging strategies and minimizing the energy costs.
There is plenty of historical volatility studies which are analyzed various electricity markets all over the world.

1. Dahlgren et al. (2001)- Californian market prices
2. Benini et al. (2002) -Californian, PJM, Spanish, and UK markets
3. Li and Flynn (2004)-(14) electricity markets worldwide
4. Woo et al. (2004)- stochastic day-ahead consumption volumes and forward contracts of electricity prices
5. Näsäkkälä and Keppo (2005) - the hedging strategies
6. Worthington et al. (2005) -Australian electricity markets
7. Mount et al. (2006) – the effect of extreme cases
8. Kanamura and Ohashi (2007)- the relationship between demand and prices in energy markets
9. Huisman at al. (2009)- successful hedging portfolio
10. Cevik and Sedik (2011)- the dynamic relationship between energy markets
The characteristics of electricity markets

• Since the electricity cannot be stored in an efficient way, the electricity prices are observed to be volatile, and also seasonality frequently occurs.
• In order to overcome this problem and to support trading of energy contracts many countries have launched over-the-counter (OTC) and organized markets.
• It is a fact that these large fluctuations in the energy prices raised major questions waiting to be answered by the researchers.
• One such question is whether the fluctuations in electricity market prices lead to similar behavior in prices of future crude oil contracts, i.e. how is the volatility spillover mechanism between electricity spot prices and prices of future crude oil contracts.
• And if so, what is the structure and causality of this relationship? The answers to these questions are important for investors, traders and policy makers.
The Electricity Market Mechanism in Turkey (1/3)

- The major reform steps are taken in the 2000’s to catch up the competitive market needs and expectation for the steadily growing Turkish Economy which are also essential for the harmonization with EU legislations and energy regulations.
- The Electricity Market Law (EML) in 3 March, 2001 with the Law No. 4628. The key objective stated in the Law was briefly “providing affordable, sustainable and quality electricity to consumers in a competitive environment”.
- As an initial step to these reforms, the Turkish Electricity Generation and Transmission Co. (TEAS) was divided into three major organizations in 2001.
The Electricity Market Mechanism in Turkey (2/3)

- Turkish Electricity Market was launched in 2006. This event could be treated as a new and revolutionary period in Turkish Energy Markets since the electricity spot prices are determined by the market conditions thereafter.
- There was an amendment and advancement in the electricity price determination system in 2009 in order to enhance the electricity pricing mechanisms.
- In this respect, the volatility of electricity prices becomes the major explanatory variable for the forecast of electricity price demand in Turkey.
The Electricity Market Mechanism in Turkey (3/3)

- It is important for the markets participants to analyze and compare historical price behavior across the energy markets, along with a forecast of price volatility which provide price signals which can be incorporated into their inter-jurisdiction energy trade planning.
- In addition, these market participants may consider price volatility signals in their future investment plans in order to minimize the potential financial risks to which they might be exposed.
- However there is neither electricity nor any other energy futures market which makes it difficult for the market participants to utilize as hedging instruments in Turkey.
Development Process of Turkish Electricity Market

08.2006 – 11.2009 Transition Period
- Balancing Mechanism
- Monthly period settlement

Stage 1
- Day Ahead Planning
- Balancing Power Market
- Hourly Settlement

Stage 2
Current Situation
- Day Ahead Market
- Balancing Power Market
- Hourly Settlement
- Collateral Mechanism

Stage 2
Final Situation
- Day Ahead Market
- Balancing Power Market
- Hourly Settlement
- Collateral Mechanism
- Intraday Market
- Physical Delivery/Financial Derivatite Contracts

1 December 2009
1 December 2011
2012...

We use the period of December 2009- May 2013

Source: TEIAS

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Data

- **TER (Turkish Electricity Return):** The daily average electricity settlement prices for the period Dec 2009 to May 2013 taken from TEIAS to calculate the return series.
- **BFR (Brent Futures Return):** The Brent Futures prices for the Dec 2009 to May 2013 from the below web link to calculate the return series.
  
  http://tonto.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RCLC1&f=D

- We consider the day effect and use dummy variables to capture the day and shocks effects

- Since electricity prices are in TL and Brent future prices are in USD, we use USD/TL exchange rates to suggest hedging strategy in the same monetary unit.

$$r_{ij,t} = \log\left(\frac{P_{ij,t}}{P_{ij,t-1}}\right)$$
The Model

\[ R_{H,t} = R_{S,t} - \gamma_t R_{F,t} \]  \hspace{1cm} (1)

- \( R_{H,t} \), where is the return on holding the portfolio between t-1 and t,

- \( R_{S,t} \) and \( R_{F,t} \) are the returns on holding spot and future positions between t and t-1,

- \( \gamma \) is the hedge ratio; in other words the number of future contracts that the hedger must sell for each unit of spot commodity on which price risk is borne.
The Model

- According to Johnson (1960), the variance of the returns of the hedge portfolio conditional on the information set available at time $t-1$ is given by:

$$\text{var}(R_H,t | \Omega_{t-1}) = \text{var}(R_S,t | \Omega_{t-1}) - 2\gamma_t \text{cov}(R_S,t, R_F,t | \Omega_{t-1}) + \gamma_t^2 \text{var}(R_F,t | \Omega_{t-1})$$  \hspace{1cm} (2)

The optimal hedge ratio are defined as the value of $\gamma$ which minimizes the conditional variance (risk) of the hedge portfolio returns. By taking the partial derivatives of the equation with respect to $\gamma$, setting it equal to zero and solving for $\gamma$ gives the optimal hedge ratio available at $t-1$ (Baillie and Myers, 1991).
The Model

\[ \gamma^*_t \mid \Omega_{t-1} = \frac{\text{cov} \left( R_{S,t}, R_{F,t} \mid \Omega_{t-1} \right)}{\text{var} \left( R_{F,t} \mid \Omega_{t-1} \right)} \]  

(3)

where returns are defined as the logarithmic differences of spot and futures prices. From the multivariate conditional volatility model, the conditional covariance matrix is obtained, such that the optimal hedge ratio is given as:

\[ \gamma^*_t \mid \Omega_{t-1} = \frac{h_{SF,t}}{h_{F,t}} \]  

(4)
# Descriptive Statistics

<table>
<thead>
<tr>
<th>Variables</th>
<th>TER</th>
<th>BFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.115429</td>
<td>0.000392</td>
</tr>
<tr>
<td>Median</td>
<td>0.006558</td>
<td>0.000000</td>
</tr>
<tr>
<td>Maximum</td>
<td>7.488814</td>
<td>0.061214</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.944197</td>
<td>-0.075881</td>
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<tr>
<td>Std. Dev.</td>
<td>0.667747</td>
<td>0.014454</td>
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<tr>
<td>Skewness</td>
<td>5.034781</td>
<td>-0.190568</td>
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<tr>
<td>Kurtosis</td>
<td>43.59734</td>
<td>5.575956</td>
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<td>Jarque-Bera</td>
<td>88934.97</td>
<td>344.6913</td>
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<td>Probability</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Sum</td>
<td>140.8235</td>
<td>0.478627</td>
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<tr>
<td>Sum Sq. Dev.</td>
<td>543.5344</td>
<td>0.254659</td>
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<tr>
<td>Observations</td>
<td>1220</td>
<td>1220</td>
</tr>
</tbody>
</table>
# Unit Root Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>ADF Unit Root Test with Constant</th>
<th>Philips Perron Unit Roots Test with Constant</th>
<th>Kwiatkowski-Phillips-Schmidt-Shin with Constant</th>
<th>Geweke Porter–Hudak Fractional Unit Root Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>BFR</td>
<td>-26.12*</td>
<td>-35.19*</td>
<td>0.73</td>
<td>0.44* (0.00)**</td>
</tr>
<tr>
<td>TER</td>
<td>-5.01</td>
<td>-39.13</td>
<td>0.73</td>
<td>0.42 (0.64)**</td>
</tr>
<tr>
<td></td>
<td>*%1 -3.43, %5 2.86</td>
<td>**%1 0.46, %5 0.34</td>
<td>**prob values</td>
<td></td>
</tr>
</tbody>
</table>

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Empirical Findings

• Starting with the seminal paper of Engle (1982), traditional time series tools such as autoregressive moving average (ARMA) models (Box and Jenkins, 1970) for the mean have been extended to essentially analogous models for the variance.

• We observe that Autoregressive conditional heteroscedasticity (ARCH) models are frequently used to illustrate and forecast changes in the volatility of high frequency financial time series. For a survey of ARCH-type models, see Bollerslev et al. (1992, 1994), Bera and Higgins (1993), Pagan (1996), Palm (1996) and Shephard (1996), among others.

• The common application of MGARCH (multivariate GARCH) models is based on the study of the relations between the volatilities and co-volatilities of several markets.

• We try various approaches namely diagonal BEKK (Engle and Kroner, 1995) CCC (Bollerslev, 1990), DCC (Engle, 2002 and Tse and Tsui, 2002), the dynamic equicorrelation -DECO (Engle and Kelly, 2007)

• We finally decide to use the diagonal BEKK since it provides the only positive variance coefficients condition during the model estimation process.
## Diagonal BEKK

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TER-SAT</td>
<td>-0.068804</td>
<td>0.014018</td>
<td>-4.908393</td>
<td>0.0000</td>
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<td>TER-SUN</td>
<td>0.269861</td>
<td>0.015642</td>
<td>17.25197</td>
<td>0.0000</td>
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<tr>
<td>TER-MON</td>
<td>0.160290</td>
<td>0.020841</td>
<td>7.691030</td>
<td>0.0000</td>
</tr>
<tr>
<td>TER-TUE</td>
<td>0.069910</td>
<td>0.019390</td>
<td>3.605576</td>
<td>0.0003</td>
</tr>
<tr>
<td>TER-WEN</td>
<td>0.043370</td>
<td>0.020220</td>
<td>2.144915</td>
<td>0.0320</td>
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<tr>
<td>TER-THU</td>
<td>0.007277</td>
<td>0.013253</td>
<td>0.549129</td>
<td>0.5829</td>
</tr>
<tr>
<td>TER-FRI</td>
<td>0.028184</td>
<td>0.015633</td>
<td>1.802833</td>
<td>0.0714</td>
</tr>
<tr>
<td>EPDK</td>
<td>-0.051348</td>
<td>0.010522</td>
<td>-4.879958</td>
<td>0.0000</td>
</tr>
<tr>
<td>BFR-MON</td>
<td>0.001757</td>
<td>0.000855</td>
<td>2.054747</td>
<td>0.0399</td>
</tr>
<tr>
<td>BFR-TUE</td>
<td>0.000817</td>
<td>0.000810</td>
<td>1.009558</td>
<td>0.3127</td>
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<tr>
<td>BFR-WEN</td>
<td>0.001473</td>
<td>0.000785</td>
<td>1.877670</td>
<td>0.0604</td>
</tr>
<tr>
<td>BFR-THU</td>
<td>-0.003405</td>
<td>0.000857</td>
<td>-3.975581</td>
<td>0.0001</td>
</tr>
<tr>
<td>BFR-FRI</td>
<td>0.000291</td>
<td>0.002185</td>
<td>0.133136</td>
<td>0.8941</td>
</tr>
</tbody>
</table>

### Variance Equation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>z-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \mu_{11} )</td>
<td>0.012857</td>
<td>0.001670</td>
<td>7.696751</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \mu_{22} )</td>
<td>1.34E-06</td>
<td>5.66E-07</td>
<td>2.359843</td>
<td>0.0183</td>
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<td>( \alpha_{11} )</td>
<td>1.219305</td>
<td>0.029283</td>
<td>41.63871</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \alpha_{22} )</td>
<td>0.144859</td>
<td>0.012750</td>
<td>11.36151</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \beta_{11} )</td>
<td>0.612583</td>
<td>0.010583</td>
<td>57.88255</td>
<td>0.0000</td>
</tr>
<tr>
<td>( \beta_{22} )</td>
<td>0.986314</td>
<td>0.002469</td>
<td>399.4087</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

| Log likelihood | 2681.626 | Schwarz criterion | -4.285432 |
| Avg. log likelihood | 1.099027 | Hannan-Quinn criter. | -4.335027 |
| Akaike info criterion | -4.364961 | | |

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Optimal Hedge Ratio

\[ \gamma^*_t \mid \Omega_{t-1} = \frac{\text{cov}(R_{S,t}, R_{F,t} \mid \Omega_{t-1})}{\text{var}(R_{F,t} \mid \Omega_{t-1})} \]

- Based on first formula; the ratio of conditional covariances of TER and BFR (Cov TER, BFR) to Var (BFR), the optimal hedge ratio for Turkish Electricity Market prices is equal to 0.4844.
- There is a need for approximately 0.5 petrol future position to hedge every one unit electricity spot price.

\[ w_{SF,t} = \frac{h_{F,t} - h_{SF,t}}{h_{S,t} - 2h_{SF,t} + h_{F,t}} \]

- Based on second formula; the optimal hedge ratio for Turkish Electricity Market prices is equal to 0.000105.
- This indicates that the petrol futures are the right hedging instrument for Turkish Electricity Market prices by providing almost optimal efficiency.
Concluding Remarks

• Based on a thorough liberalization process, the Turkish Electricity Market mechanisms are continually changing. The goal of Turkish Electricity Market liberalization is basically to increase the economic efficiency of the electricity supply industry.

• The introduction of competition in the generation and retail supply of electricity is expected to improve efficiency by minimizing operating costs.

• In addition, it is essential to use hedging instruments. We recommend for policy makers to consider this fact and establish energy futures market in Turkey shortly. Until that time, the petrol futures could be used as hedging instrument for Turkish electricity market.
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