Ing. Štěpán Kratochvíl

FORECASTING OF ELECTRICITY PRICE VOLATILITY

CONTENT OF PREZENTATION

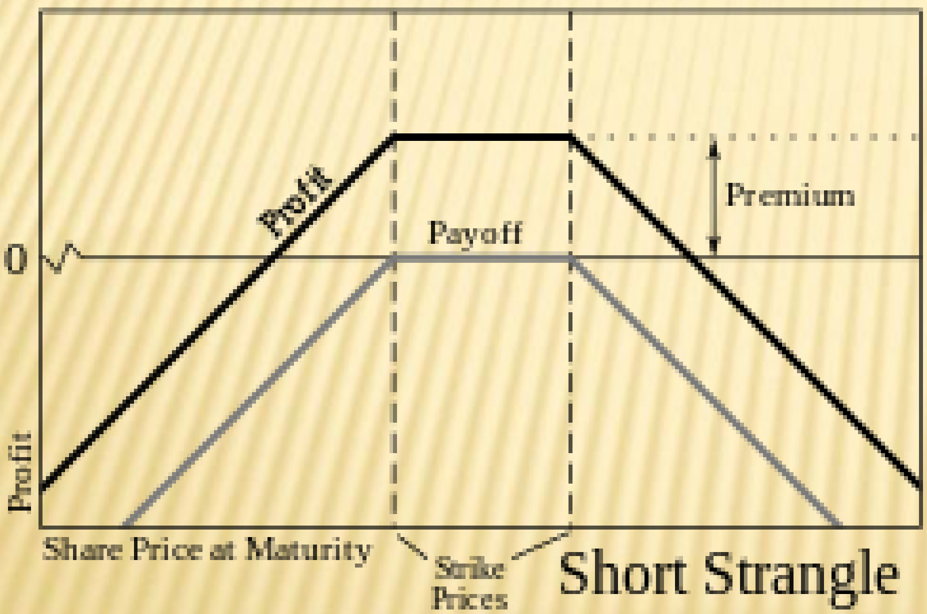
- Why predict the electricity volatility?
- Input data
- Stochastic part estimation
- Standard methodology – EGARCH
- Realized measures
- Realized GARCH
- Realized EGARCH
- Results
- Conclusion

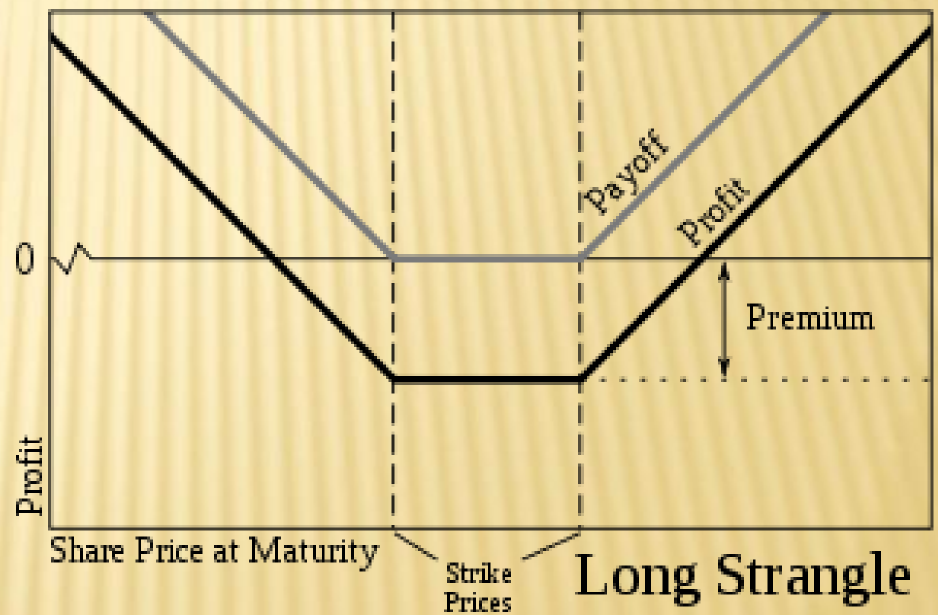
WHY PREDICT THE ELECTRICITY VOLATILITY?

- Increasing amount of electricity traded on energy exchange
- Increasing share of RES in energy generation
- Risk management
- Features of the electricity price (mainly non-storability)
- Usefull for both electricity producers and consumers

HEDGING AGAINST VOLATILITY MOVEMENTS

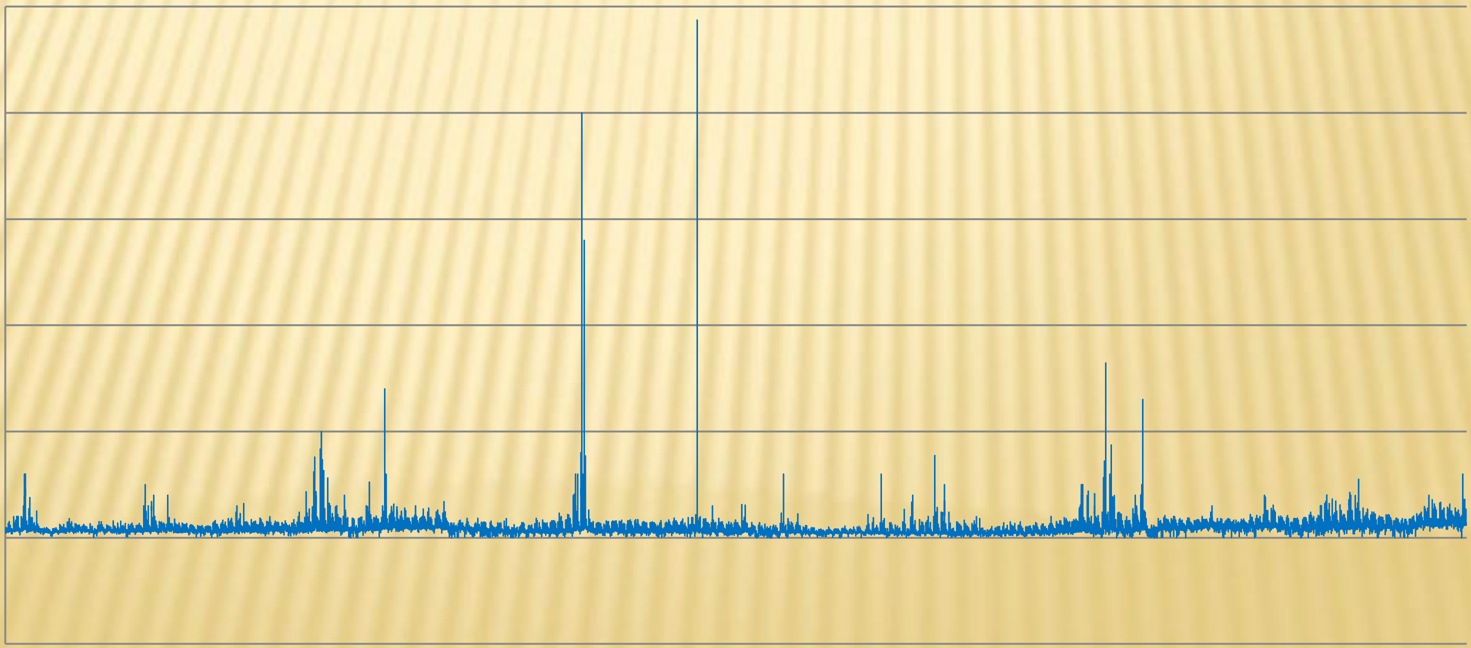
- Options straddle and strangle





FEATURES OF THE ELECTRICITY PRICE

- High mean-reverting rate
- Occasion of price jumps
- Very high volatility
- Negative prices

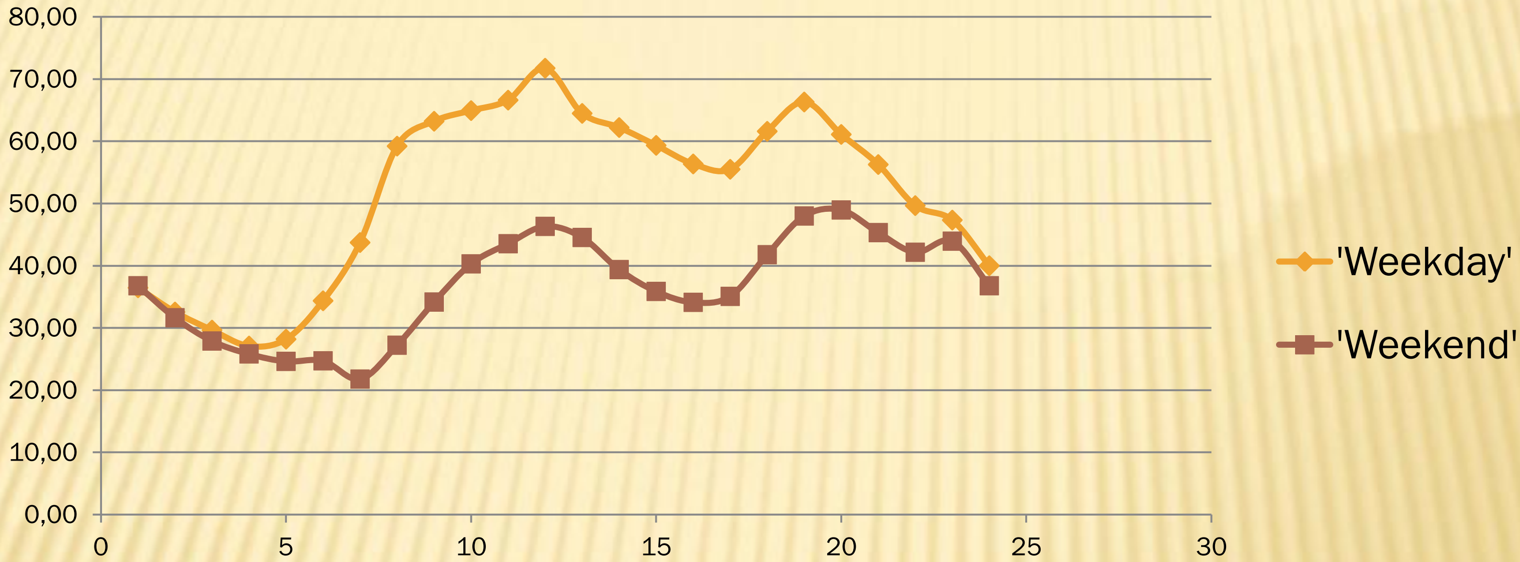


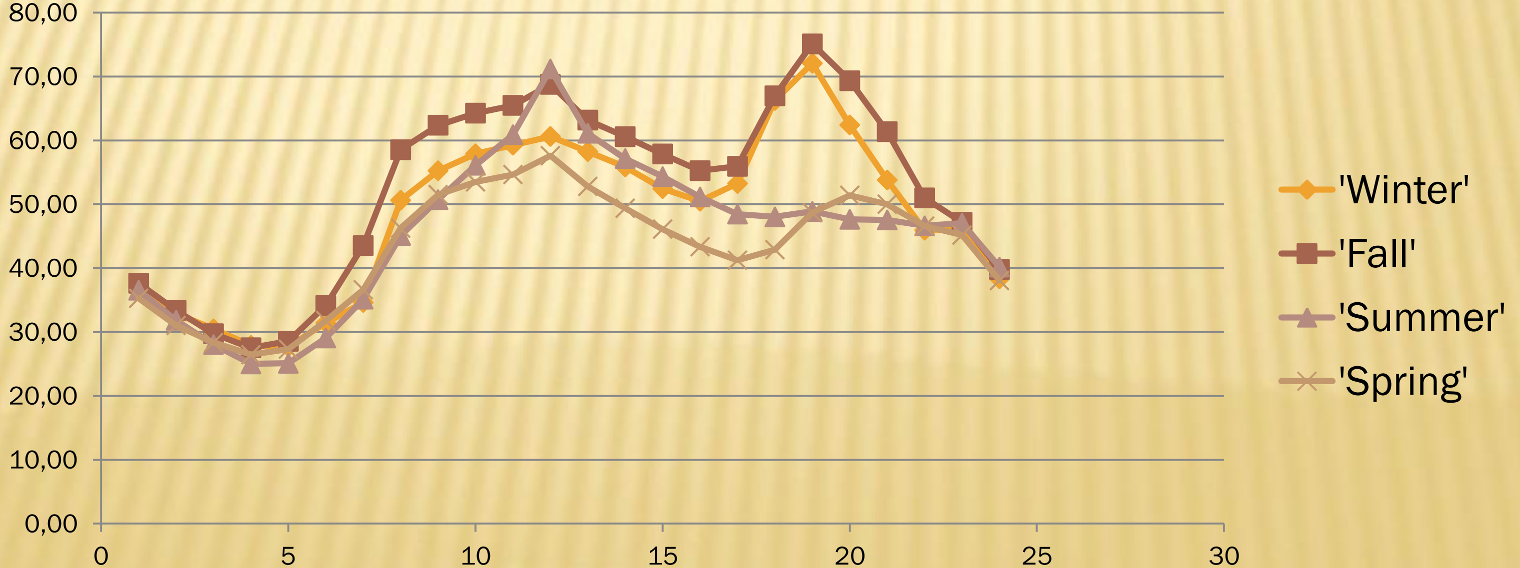
INPUT DATA

- European Power Exchange (EPEX), Phelix base index
- 2951 daily observations from February 2005 to April 2013 - the last 804 observations for an out-of-sample evaluation

	Full Sample	Weekday	Weekend	Spring	Summer	Fall	Winter	Holiday
Obs.	2951	2109	842	750	736	728	737	71
Mean	47.34	51.58	36.70	43.17	45.54	52.40	48.36	26.55
Median	45.50	48.92	36.18	41.61	43.54	50.15	47.42	27.87
Std Dev	18.13	18.48	11.79	14.14	19.13	19.70	17.83	18.99
Min	-56.87	-56.87	-35.57	9.93	13.63	-11.59	-56.87	-56.87
Max	301.54	301.54	82.82	104.60	301.54	162.2	158.97	71.37
Skew	2.21	2.56	0.10	0.65	4.86	1.81	0.15	-2.15
Kurt	22.47	25.81	4.97	3.75	55.74	8.19	8.07	10.85
25%	36.51	40.90	28.46	33.52	35.29	41.10	37.49	21.15
75%	54.75	57.79	43.90	51.39	50.94	56.74	57.85	34.98
Negative	4	2	2	0	0	1	3	3

WEAK PATTERN AND SEASONALITY





STOCHASTIC PART ESTIMATION

- Volatility can be considered as squared stochastic component
- The stochastic component of the daily price is measured as the difference between the realized price and its conditional expectation (deterministic part of the price)

$$\varepsilon_t = p_t - E(p_t|\Omega_{t-1})$$

$$E(p_t|\Omega_{t-1}) = \alpha_0 + \alpha_1 I_t^{Weekend} + \alpha_2 I_t^{Holiday} + \alpha_3 I_t^{Spring} + \alpha_4 I_t^{Fall} + \alpha_5 I_t^{Winter} + \beta p_{t-1}$$

STANDARD METHODOLOGY - EGARCH

- ε_t follows *IID*(0, h_t), h_t is the latent conditional variance on day *t*, z_{t-1} is the lagged standardized innovation, and the leverage function, $\tau(\cdot)$, is given by $\tau(z_{t-1}) \equiv \tau_1 z_{t-1} + \tau_2(|z_{t-1}| - E|z_{t-1}|)$
- mean equation and the (conditional) variance equation

$$\varepsilon_t = \sqrt{h_t} z_t$$

$$log h_t = \omega + \beta \, log h_{t-1} + \tau(z_{t-1})$$

REALIZED MEASURES

- The **realized variance**, RV_t, is defined as the summation of the squared demeaned price changes over day *t*.

$$RV_t = \sum_{j=1}^{M} r_{t,j}^2$$

$$r_{t,j} = p_{t,j}^* - p_{t,j-1}^*, \qquad j = 1, \dots, M, \qquad t = 1, \dots, T$$

- The (squared) **intraday range** is defined as the squared difference between the maximum and minimum price within the day.

$$IR_t = (\max_j p_{t,j} - \min_j p_{t,j})^2, \quad j = 1, \dots, M, \quad t = 1, \dots, T$$

REALIZED GARCH

- ε_t, h_t and z_t retain the same definitions as in EGARCH model. x_t is the realized measure, the leverage function $\delta(\cdot)$ is given by $\delta(z_t) \equiv \delta_1 z_t + \delta_2(z_t^2 - 1)$, and the measurement error u_t follows *IID*$(0, \sigma_u^2)$.
- mean equation, variance equation and the measurement equation

$$\varepsilon_t = \sqrt{h_t} z_t$$

$$logh_t = \omega + \beta\, logh_{t-1} + \gamma\, logx_{t-1}$$

$$logx_t = \xi + \varphi\, logh_t + \delta(z_t) + u_t$$

REALIZED EGARCH

- the leverage function $\tau(\cdot)$ enters directly into the variance equation.
- the current level of the latent volatility is governed by its own persistence ($\beta\ logh_{t-1}$), the asymmetric shock from the prior period ($\tau(z_{t-1})$), and the multiple volatility indicators of realized measures ($\gamma' u_{t-1}$)

$$\varepsilon_t = \sqrt{h_t} z_t$$

$$logh_t = \omega + \beta\ logh_{t-1} + \tau(z_{t-1}) + \gamma' u_{t-1}$$

$$logx_{k,t} = \xi_k + \varphi_k\ logh_t + \delta_k(z_t) + u_{k,t} \qquad k = 1, \cdots, K$$

OUT OF SAMPLE RESULTS - 1

	EGARCH	Real-GARCH_RV	Real-GARCH_RG	Real-EGARCH_RV	Real-EGARCH_RG
Panel A: Out-of-sample forecasting evaluation, rolling scheme					
MSE	8.698	8.652	8.561	8.776	8.740
MdSE	1.977	1.797	1.787	1.903	1.864
MAE	2.045	2.027	2.023	2.045	2.044
MdAE	1.406	1.341	1.337	1.379	1.365
MALE	0.931	0.927	0.927	0.930	0.931
MdALE	0.380	0.379	0.362	0.391	0.373
MAPE	272.463	267.638	266.997	269.846	271.199
MdAPE	42.207	44.122	40.617	46.406	43.010
Panel B: Out-of-sample forecasting evaluation, recursive scheme					
MSE	8.700	8.643	8.563	8.745	8.736
MdSE	1.956	1.812	1.778	1.911	1.841
MAE	2.045	2.028	2.026	2.040	2.046
MdAE	1.399	1.346	1.333	1.382	1.357
MALE	0.930	0.927	0.928	0.929	0.931
MdALE	0.377	0.377	0.362	0.382	0.372
MAPE	272.358	267.451	266.744	269.861	270.993
MdAPE	42.531	44.325	40.696	45.349	43.034

OUT OF SAMPLE RESULTS - 2

- exploring the relative predicting power among competing forecasting models

$$logRV_{t+1} = \alpha + \beta_1 \hat{v}_{t+1}^{EGARCH} + \beta_2 \hat{v}_{t+1}^{Real} + \varepsilon_{t+1}$$

	Real-GARCH_RV	Real-GARCH_RG	Real-EGARCH_RV	Real-EGARCH_RG
alpha	3.670***	3.718***	4.331***	4.078***
	0.358	0.310	0.420	0.346
beta_1	-0.034	0.024	-0.111**	-0.131***
	0.054	0.048	0.056	0.046
beta_2	0.877***	0.819***	0.782***	0.871***
	0.077	0.054	0.095	0.076
adj. R^2	0.193	0.214	0.176	0.203

CONCLUSION FROM REACHED RESULTS

- the incorporation of the information content from realized volatility measures (eg. intraday range or realized variance) significantly improves the accuracy of out-of-sample volatility forecasts
- the Realized GARCH model based on the intraday range offers superior out-of-sample forecasting performance as compared to other competing models, stressing the benefits of using range-based measures as efficient volatility indicators

CONCLUSION – FUTURE WORK?

- Fields of future research?
  - Using exogenous variables?
    - Solar forecast
    - Wind forecast
    - Consume forecast
    - Temperatures forecast
    - Cross-boarder flows
  - Jump detection and forecasting?
  - Using another realized measures?

THANK YOU FOR YOUR ATTENTION