

Lacima/EEX risk management workshop

# Multivariate analysis in energy trading

(エネルギートレーディングにおける多変量解析)

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# The world of energy trading

p1



- Huge amount of diverse data
- People called “traders” who navigate in the sea of data
- Profits and losses generated from moment to moment
- Data as management indicators
- Data analysis and strategy feedback
- ETRM system placed at the center of business

# Definition of risk management...possible?

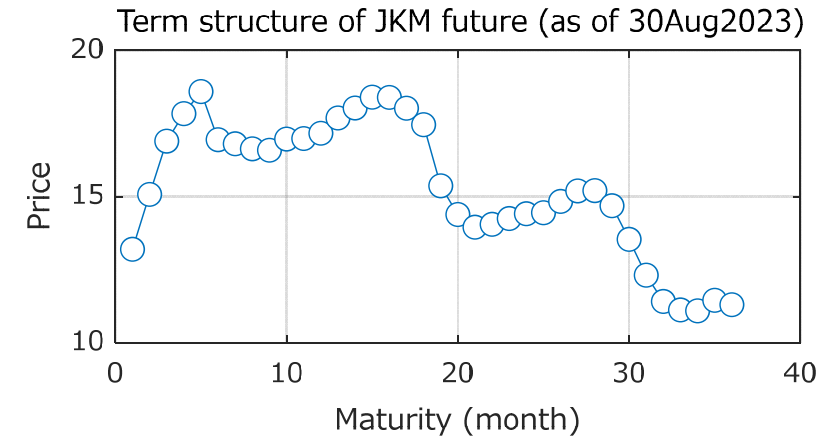
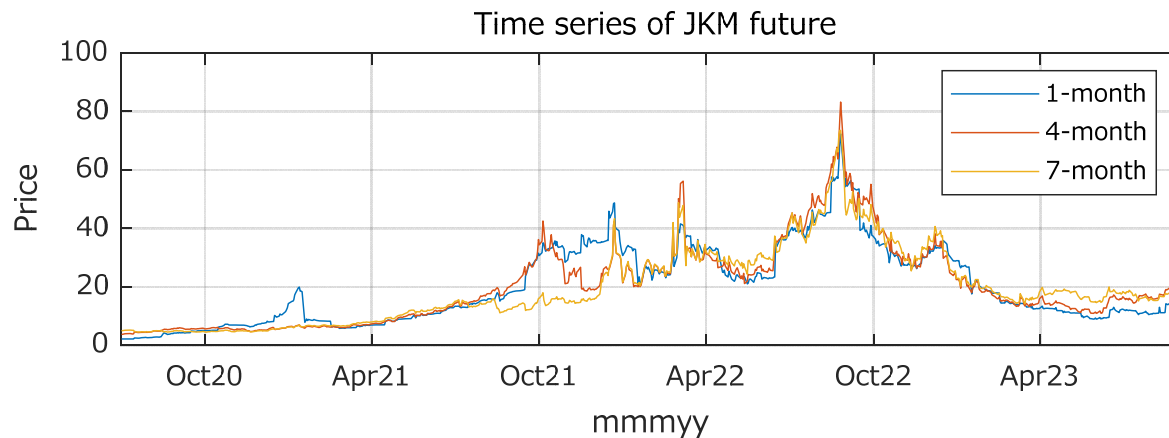
p2



- A concept, not a job category
- Entangled with the world of energy trading
- To understand the whole, need to stack a single point of view such as VaR, Margin, ETRM system...etc.
- **Data analysis on forward curve** is selected as the point of view in this presentation

# What is forward curve?

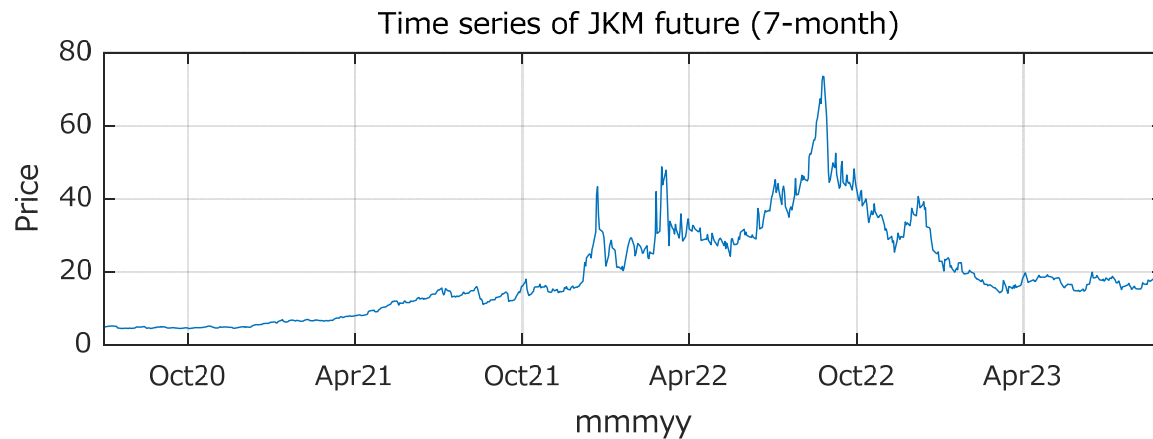
p3



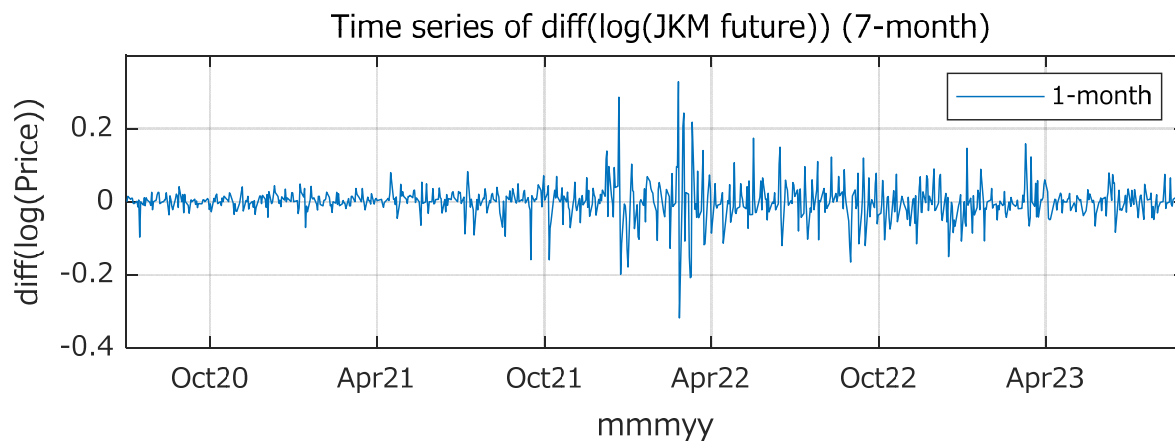
- Not a forecast
- Dimension of maturity is “TIME”, but it never indicates “real time horizon”.
- Current fixed price of goods delivered in the future
- Fact per se that happening in the market
- “Everyone’s opinion is quite correct” theory

# What is volatility?

p4

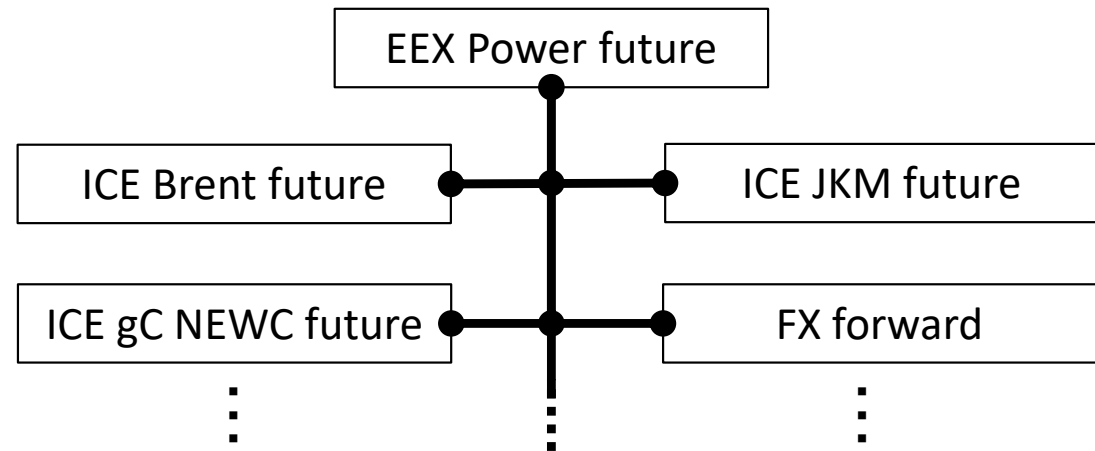
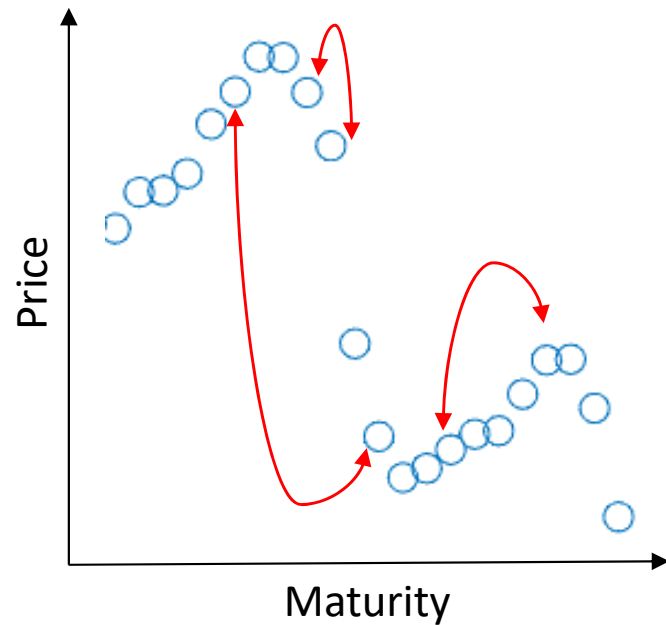


$$\triangleright P_t$$

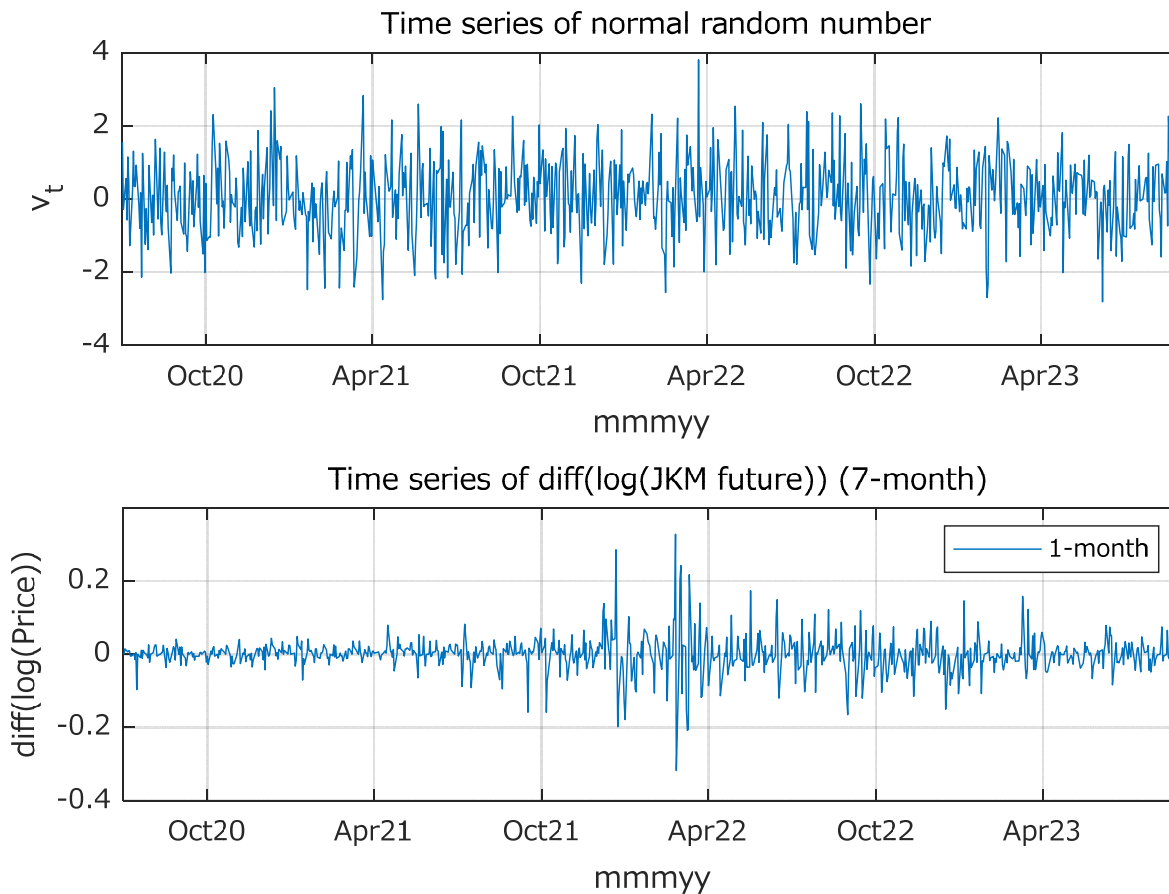


$$\triangleright \log_e \frac{P_t}{P_{t-1}}$$

- Magnitude of fluctuation
- Volatility is standard deviation of diff(log(Price))
- Time varying



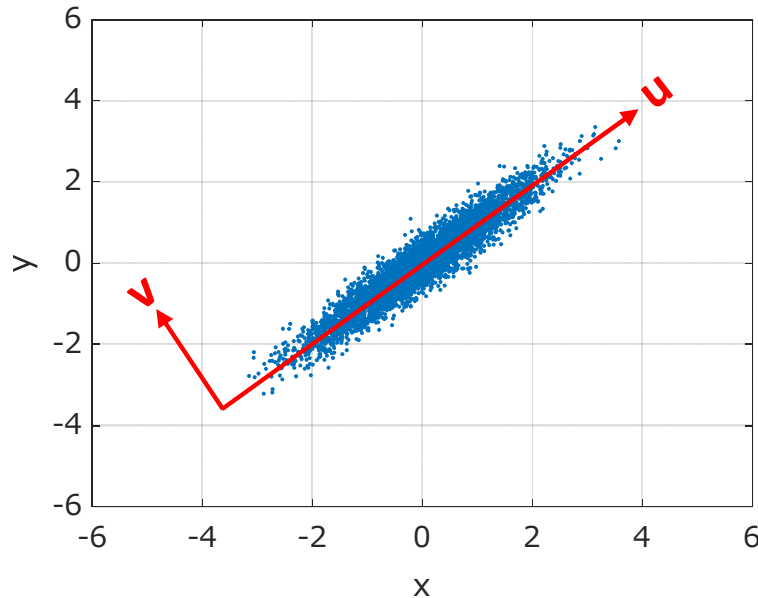
- Internal correlation among maturities of one curve
- External correlation among curves
- Exponential increase of correlation
- Time varying



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

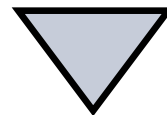
$$h_t = \kappa + \delta_1 h_{t-1} + \alpha_1 \varepsilon_{t-1}^2$$

- A time series model of time varying volatility
- Can be expanded into multivariate, but extremely troublesome



If  $\text{Variance}[u] \gg \text{Variance}[v]$ ?

- New coordinates axis that are orthogonal each other
- Reduce the number of dimensions (data sets)



- **Univariate**-GARCH can be applied to principal components the number of which is limited



## U.S. Energy Information Administration

A calculation of the day-ahead electric price divided by the day-ahead natural gas price. Implied heat rate is also known as the 'break-even natural gas market heat rate,' because only a natural gas generator with an operating heat rate (measure of unit efficiency) below the implied heat rate value can make money by burning natural gas to generate power. Natural gas plants with a higher operating heat rate cannot make money at the prevailing electricity and natural gas prices.

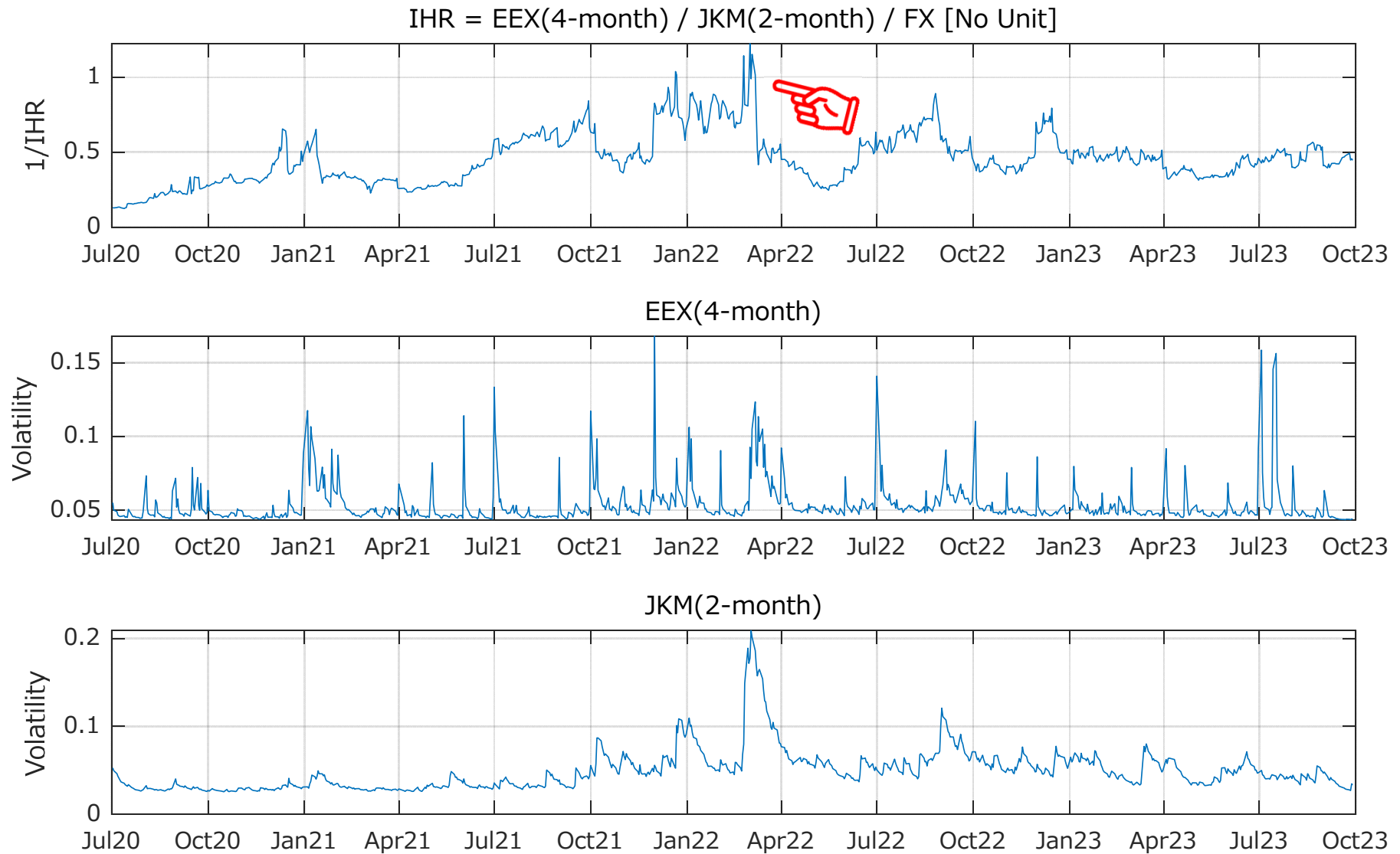
<https://www.eia.gov/tools/glossary/index.php?id=i>

$$\text{IHR} = \frac{\text{Power future price [JPY/kWh]}}{\frac{\text{LNG future price [USD/MMBtu]}}{293 \text{ [kWh/MMBtu]}} \cdot \text{FX [JPY/USD]}}$$

$$\frac{1}{\text{IHR}} = \text{Implied power generation efficiency } (\approx 0.45)$$

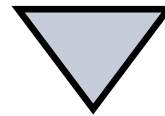
# Implied heat rate

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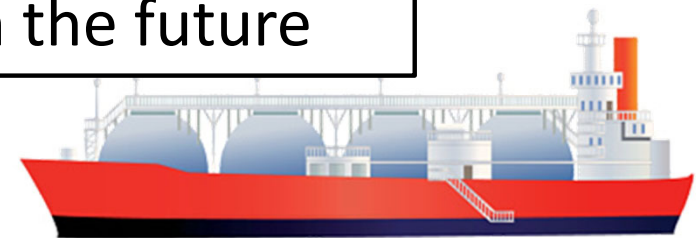




Weighted average of actual procurement prices  
(including long-term contract)



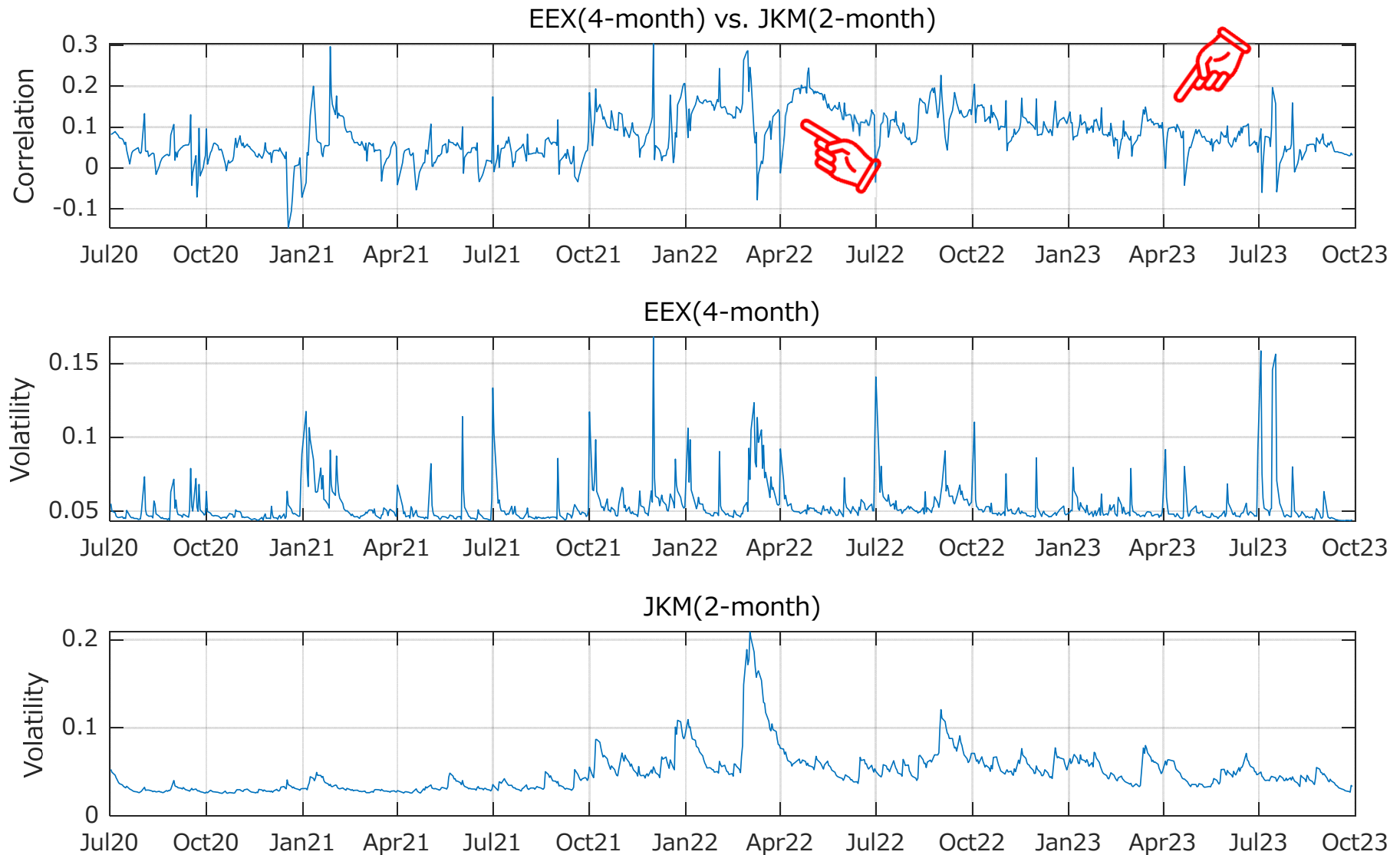
Price to be additionally procured in the future



- JERA and Tohoku EPCO in November 2021
- Hokkaido EPCO in April 2022
- Expectation for active spark spread trading

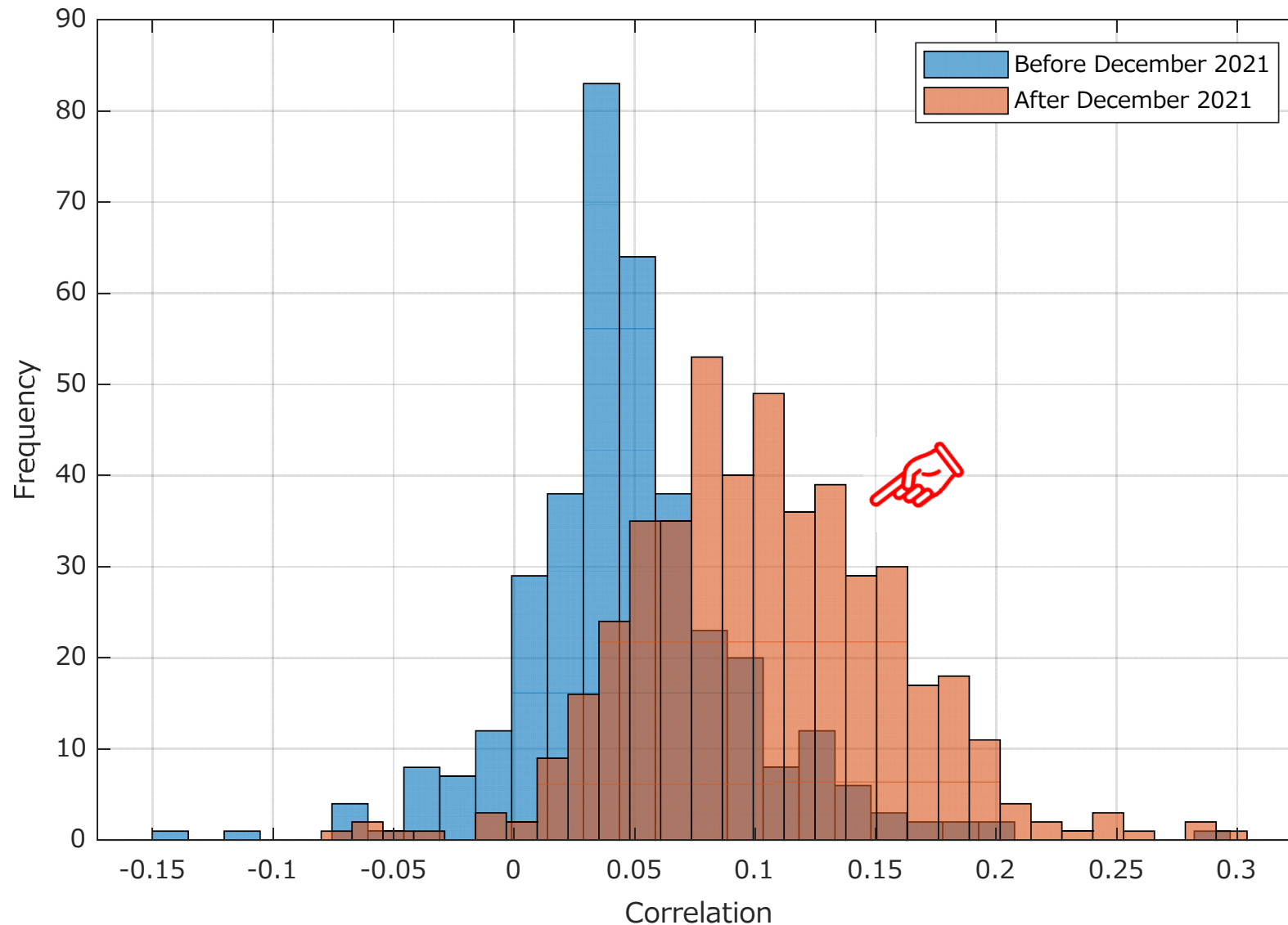
# Correlation between EEX power future and JKM future

p11



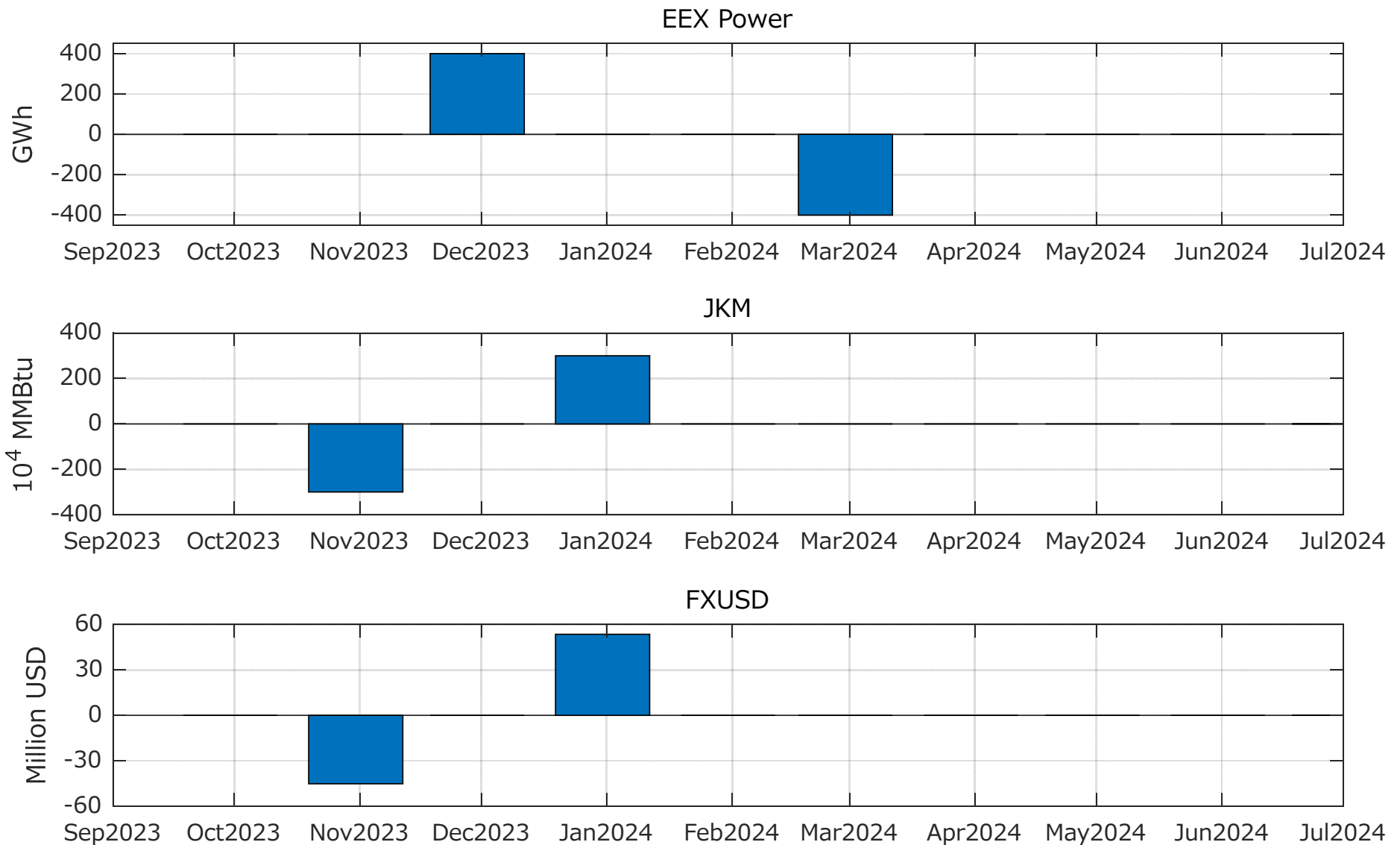
# Comparison of correlation before and after Dec 2021

p12



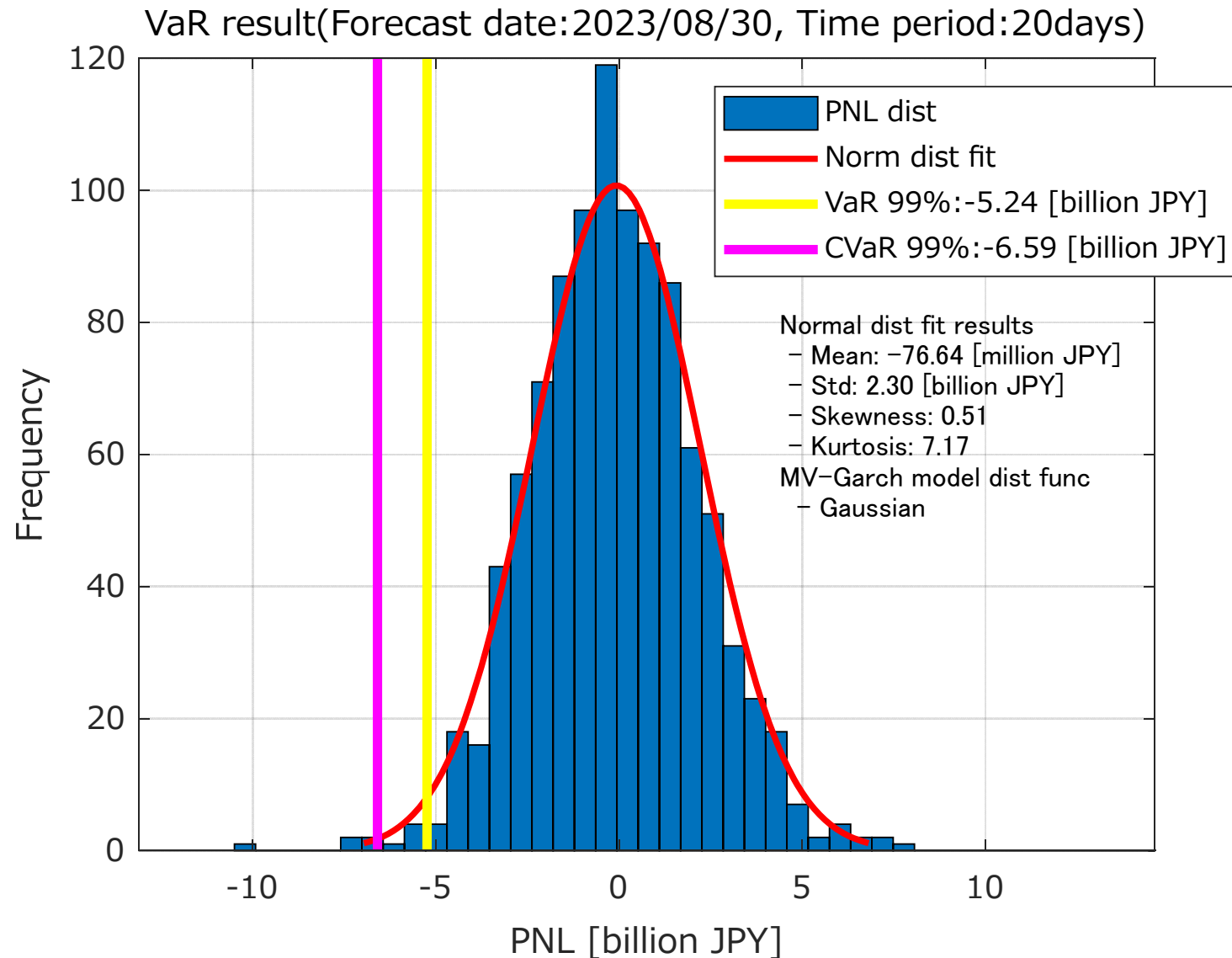
# A model of position (as of 30Aug2023)

p13



# Value at risk of the model position

p14



**Loss from curve  $i$ ;**  $X_i$

**Condition A ;**  $\text{abs}(\sum_i X_i) \geq \text{abs}(\text{VaR99\%})$

**Indicator vector  $I_A$ ;** 1 (Condition A is satisfied)  
0 (Condition A is NOT satisfied)

**CVaR ;**

$$E \left[ I_A \cdot \sum_i X_i \right] = \underbrace{\sum_i E[I_A \cdot X_i]}$$

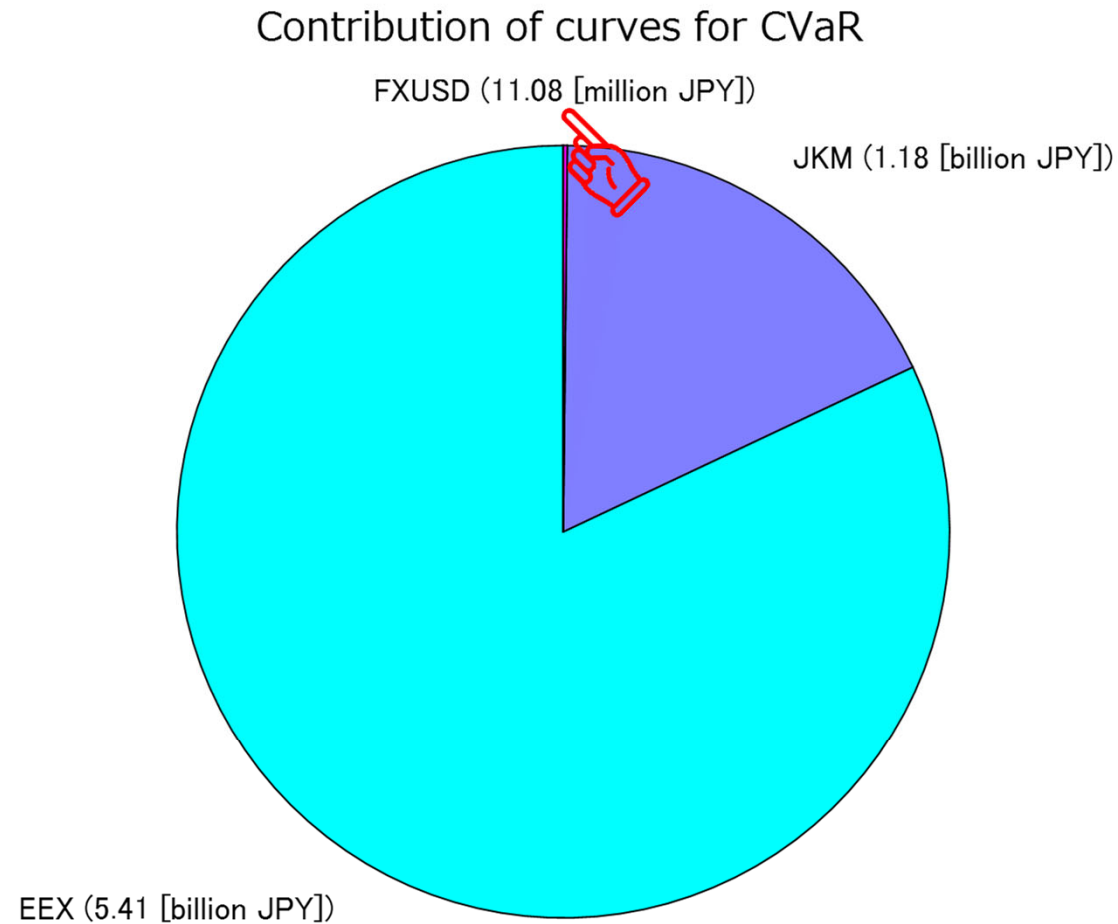


CVaR can be decomposed to each curve contribution.



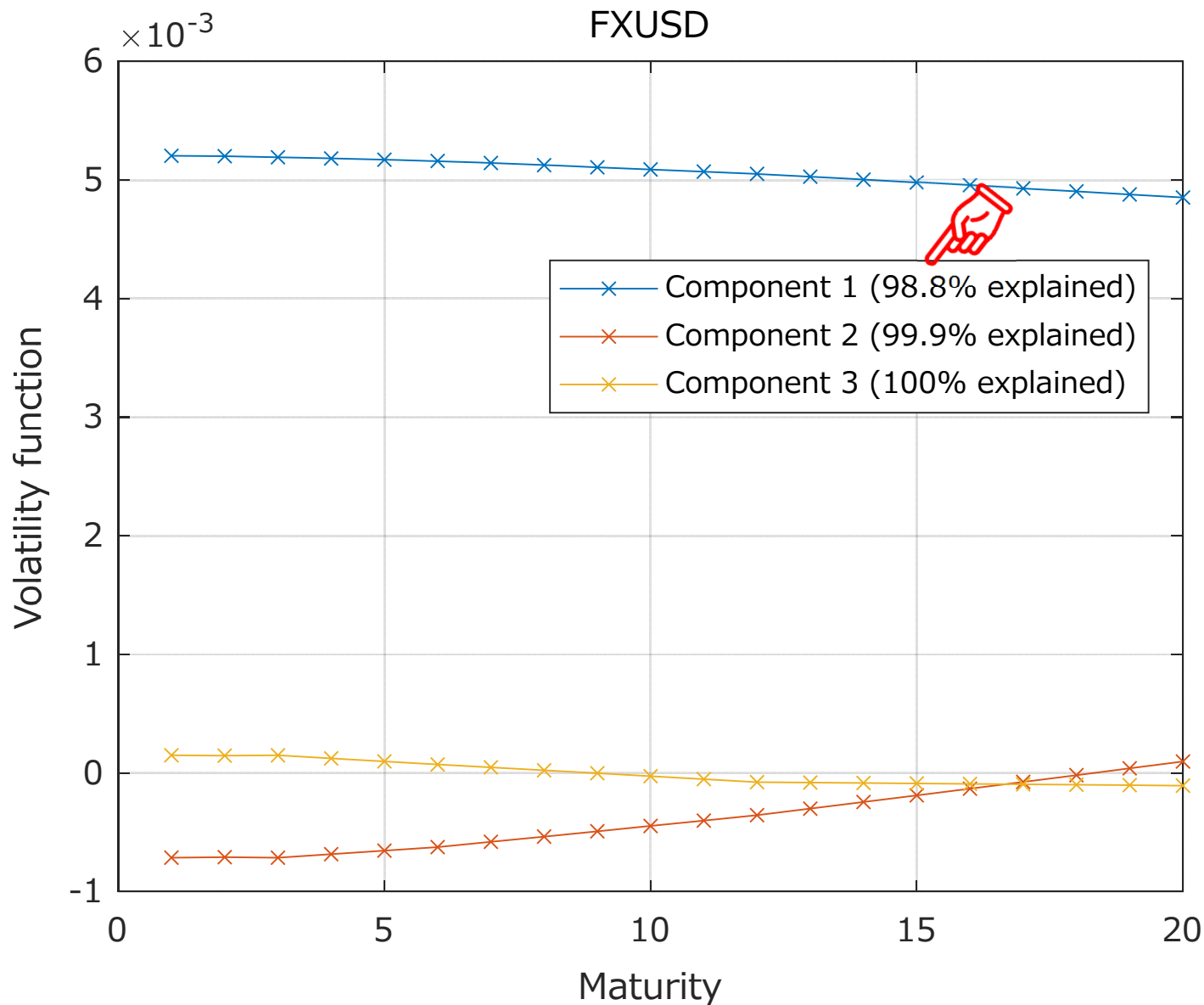
# Contribution of each curve on CVaR

p16



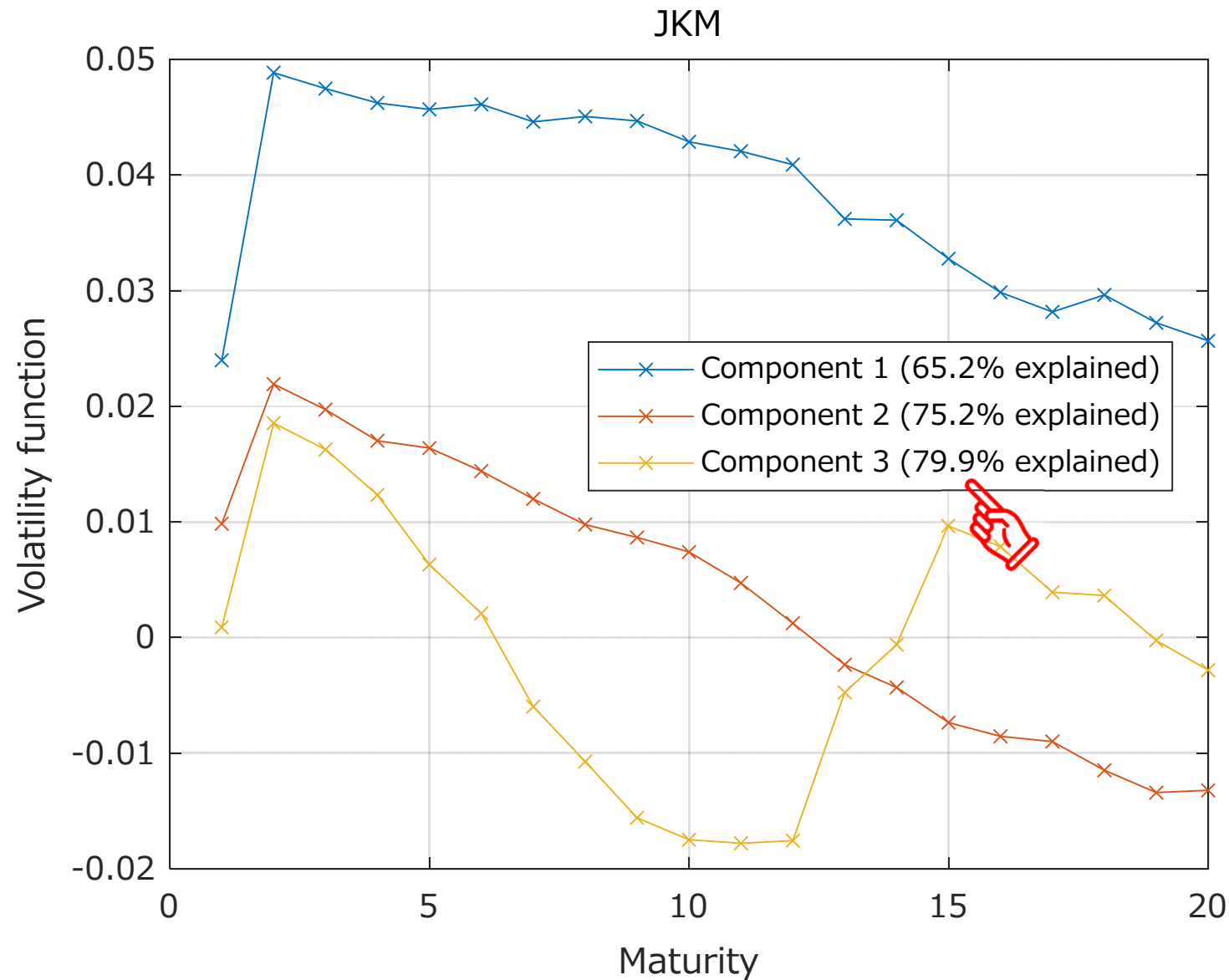
# Principal components of FXUSD future

p17



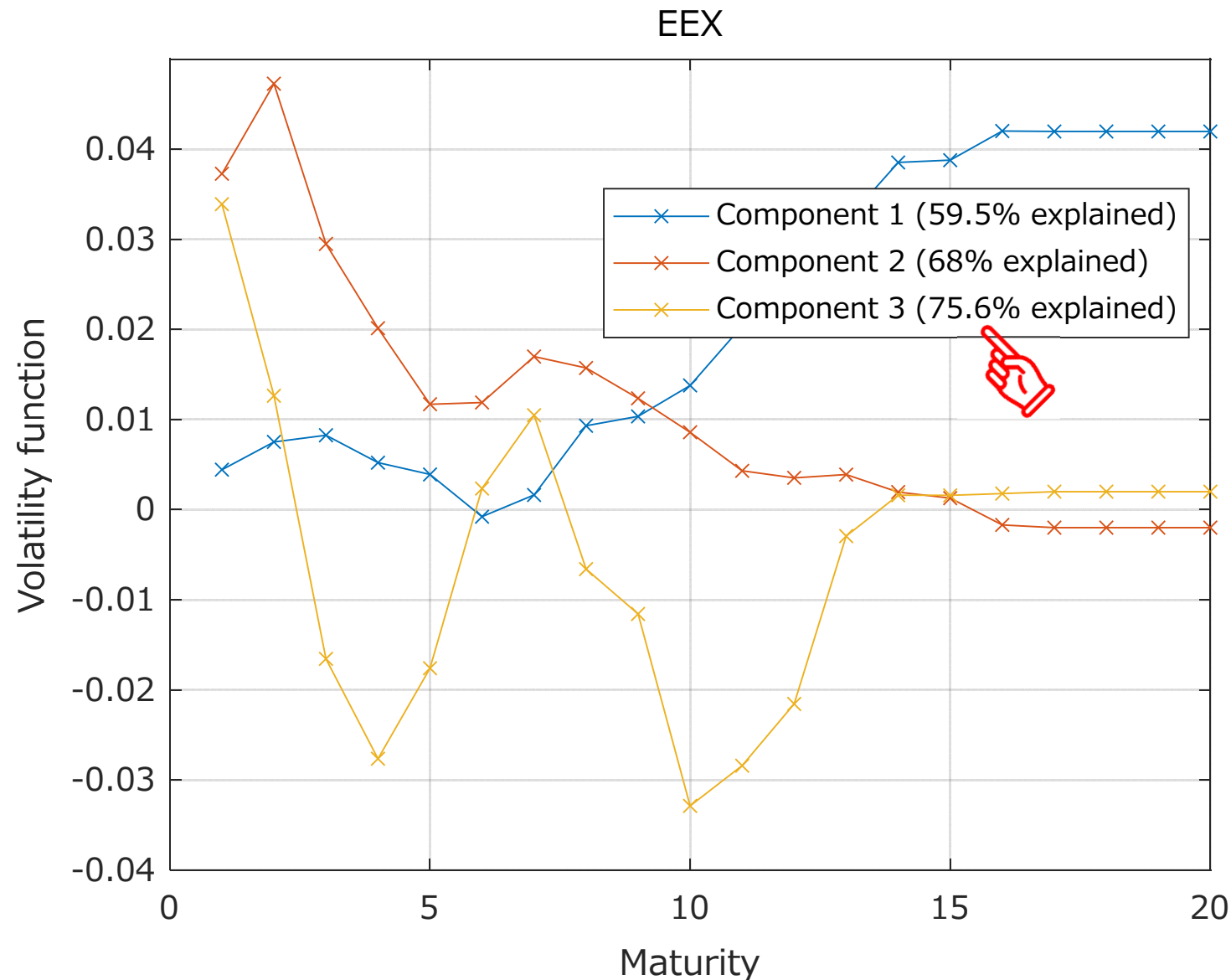
# Principal components of JKM future

p18



# Principal components of EEX power future

p19



- Data analysis is an important perspective for risk management, ultimately for the whole of energy trading.
- PCA and GARCH are one of the possible solutions to handle huge amount of time varying volatility and correlation.
- IHR and correlation between power future and LNG future may give us a hint for Japanese style spark spread trading.
- An example of portfolio was given, and its CVaR can be explained by principal components of forward curves.



**From R(=rate) to P(=price)**

“System users are divided into two types. One focuses on usability, and the other focuses on engineering.”

- A certain ETRM system vendor

Question	“Usability” user’s answer	“Engineering” user’s answer
What is system for you?	Just a tool.	A part of our own technologies.
What do you want from system?	Efficiency and automatic.	Expandability and flexibility
What do you do to realize your purpose?	Perfect requirement definition and project management.	Try to understand why the system works so.

“You are clearly the latter.” she added.

Thank you for your attention.

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