VIII Residential SUMMER SCHOOL

MODELLING AND FORECASTING ENERGY MARKETS

Florence, 24-28 June 2024

In the last two decades, energy markets operators have witnessed major structural changes that have had a profund impact on how prices are determined on the market. Events like market liberalization, adoption of energy efficiency regulation, increased production from renewable energy sources, and climate change have contributed in making the demand and supply less predictable and the prices more volatile. The accurate modelling and forecasting of energy demand and prices has become of utmost importance, not only to energy producers themselves, but also to commodity traders and financial analysts focusing on the energy sector. The statistical features of energy data, which tends to follow periodic patterns and exhibit spikes, non-constant means and non-constant variances, renders the task of forecasting and modelling of energy data somewhat challenging.

The objective of TStat's "Modelling and Forecasting Energy Markets" Summer School is therefore to provide participants with the specific analytical tools to undertake a rigorous and in-depth analysis of both demand and prices in international energy markets.

The programme covers a wide range of econometric methods currently available to researchers and practitioners, such as: i) univariate and multivariate time series models for forecasting prices and energy demand, Markov-switching models and testing bubble episodes; in energy markets ii) univariate and multivariate GARCH models for forecasting price volatility, and iii) cointegration models and panel data models for assessing the sensitivity of energy demand to price, income and climate variables and for constructing long-run policy scenarios.

Following TStat's training philosophy, the teaching style features both theoretical sessions, where participants are given the intuition behind the choice of a specific technique, and several practical sessions using econometric software. In this manner, the course leaders are able to bridge the "often difficult" gap between abstract theoretical methodologies, and the practical issues one encounters when dealing with real data.

The 2024 edition also includes a presentation participants' case study session during which participants will either work in small groups on a short applied case study or on a presentation of their own research work. Course leaders will discuss with participants the appropriateness of the methods adopted in their case study and the interpretation of the results obtained and will also provide feedback and guidance on possible future developments of individual research agendas.

At the end of the School participants are expected to be in a position to autonomously conduct energy markets analysis. In particular, participants will be able to evaluate which econometric method is more appropriate to the analysis in hand and will be able to test the appropriateness of their estimated model and the robustness of the results obtained.

SUMMER SCHOOL CODE

I-SS12

TARGET AUDIENCE

Researchers and professionals working either: i) in the energy and related sectors, needing to model energy price and demand, and ii) on trading desks in financial institutions. Economists based in research policy institutions. Students and researchers in engineering, econometrics and finance needing to learn the econometrics methods and tools applied in this field.

PREREQUISITES

Participants are required to have a good working knowledge of:

- Linear regression model definition and assumptions;
- Ordinary Least Squares (OLS) estimation. Properties of OLS;
- Inference in the linear regression model: confidence intervals, t-test, F-test;
- Violation of the linear regression model assumptions: heteroscedasticity, serial correlation, functional form misspecification, non-Normality. Diagnostic analysis of regression. Consequences of violations and remedies.

Attendees do NOT however, require any previous knowledge of the software *Stata*.

These topics are covered in all the introductory econometrics textbooks, for example:

- Brooks, C. (2019). *Introductory Econometrics for Finance*. Cambridge University Press. Chapters: 3-5.
- Wooldridge, J. M. (2020). *Introductory Econometrics: A Modern Approach*. Seventh Edition. Cengage Learning. Chapters: 2-12.

PROGRAMME

DAY 1 — ENERGY DATA ANALYSIS

SESSION I: AN INTRODUCTION TO ENERGY DATA

1. Data cleaning and data preparation (creating logs, log-differences);
2. Graphical analysis of energy time series: line plots, distribution plots, sample correlograms;
3. Understanding non-stationarity and volatility from visual inspection of the time series.

SESSION II: ENERGY DATA ANALYSIS

1. Creating tables of descriptive statistics to understand the features of energy data;
2. Test for autocorrelation and heteroscedasticity. Normality test;
3. Unit root tests for checking nonstationary of energy time series.

DAY 2 TIME SERIES MODELS AND FORECASTING

SESSION I: UNIVARIATE TIME SERIES MODELS FOR ENERGY DEMAND AND PRICES (ELECTRICITY, CRUDE OIL, NATURAL GAS...)

1. Univariate time series models for modelling and forecasting energy prices (ARMA, ARIMA, ARFIMA, SARIMA). Diagnostic tests for univariate time series models;
   - *Practical applications*: modelling and forecasting energy prices with univariate models using market data for OECD countries.

SESSION II: MODELLING AND TIMING ENERGY RISK (ELECTRICITY AND NATURAL GAS...)

2. Exogenous vs endogenous Markov-Switching models and methods to identify bubble episodes in energy time series;
   - *Practical applications*: detecting regimes and bubbles in electricity and natural gas prices for major European countries, and the impact of geo-political and climate risks.

SESSION III: MULTIVARIATE TIME SERIES MODELS FOR ENERGY DEMAND AND PRICES (ELECTRICITY, CRUDE OIL, NATURAL GAS...)

3. Vector autoregressive (VAR) models for forecasting energy prices and for understanding interdependences between energy markets;
   - *Practical applications*: modelling and forecasting energy prices with VAR models using market data for OECD countries; measuring the impact of energy shocks on inflation inequality, and of daily news on the European gas market.

4. Granger causality of energy prices;
   - *Practical applications*: causal relations between returns of Brent crude and the oil-intensive equity indices (agricultural, construction, industrial and transportation).

DAY 3 VOLATILITY MODELS AND FORECASTING

SESSION I: UNIVARIATE GARCH MODELS FOR ESTIMATING AND FORECASTING ENERGY PRICES VOLATILITY (ELECTRICITY, CRUDE OIL, NATURAL GAS...)

1. ARCH, GARCH, GARCH-in-mean and IGARCH models for energy prices. Inverse leverage effect in energy markets. Estimating asymmetric GARCH models (EGARCH, TGARCH, APARCH);
   - *Practical applications*: fitting symmetric and asymmetric GARCH models for energy prices volatility and forecasting accuracy measures.

SESSION II: MULTIVARIATE GARCH MODELS FOR ENERGY PRICES VOLATILITY AND CORRELATION (ELECTRICITY, CRUDE OIL, NATURAL GAS...)

2. VECH and Diagonal VECH models. Constant Conditional Correlation (CCC) model, Dynamic Conditional Correlation Model (DCC): Engle (2002) and Tse and Tsui (2002) specifications;
   - Practical applications: testing for interdependencies between energy markets volatility using CCC and DCC models.

DAY 4 MODELLING TRENDING BEHAVIOURS

SESSION I: COINTEGRATION MODELS OF ENERGY DEMAND (ELECTRICITY, CRUDE OIL, NATURAL GAS...)

1. An introduction to the theory of cointegration. Cointegration models for energy data: autoregressive distributed lag models and error correction models. The Engle & Granger procedure and the Johansen's approach to cointegration;
   - *Practical applications*: Estimating energy demand models using market data for OECD countries. Cointegration between oil and gas markets, and gas and power spot prices.

SESSION II: PRESENTATION PARTICIPANTS' CASE STUDY

2. Participants will be encouraged to give a short 15-min presentation on their own research projects and related data issues. Course leaders will provide feedback and guidance on how to deal with research projects.

DAY 5 PANEL DATA MODELS

SESSION I:
STATIC AND DYNAMIC PANEL DATA MODELS FOR ENERGY DEMAND (ELECTRICITY, CRUDE OIL, NATURAL GAS…)

1. An introduction to panel data analysis: types of panel data, advantages of panel data. Fixed vs random effects models in typical (large N and small T) panels. Least squares dummy variables, within, between and GLS estimators. Hausman Test. Estimators for dynamic models. Anderson and Hsiao estimator, Arellano and Bond estimator, Blundell and Bond estimator;
   - *Practical applications*: modelling and forecasting energy demand with a panel data approach using data for OECD countries.

SESSION II:
NON-STATIONARITY PANEL DATA MODELS FOR ENERGY DEMAND (ELECTRICITY, CRUDE OIL, NATURAL GAS…)

2. Unit root tests and cointegration for panels. Conditions for valid aggregation of a set of micro cointegrated economic relationships to provide a valid macro cointegrated relationship. Granger causality in panels;
   - *Practical applications*: modelling and forecasting energy demand with a panel data approach using data for OECD countries.

SUGGESTED READINGS

- Becketti, S. (2020). *Introduction to Time Series Using Stata*. Stata Press Publication.
- Boffelli, S. & Urga G. (2016). *Financial Econometrics Using Stata*. Stata Press Publication.
- Brooks, C. (2019). Introductory Econometrics for Finance. Cambridge University Press.
- Hurn, S., V.L. Martin, P.C.B. Phillips and J. Yu (2021). Financial Econometric Modeling. Oxford University Press.
- Energy Economics (various). Elsevier.
- International Journal of Forecasting (2022). Forecasting: theory and practice. Elsevier.
- Linton, O. (2019). Financial Econometrics. Cambridge University Press.
- The Energy Journal (various). International Association for Energy Economics.
- Stock, J.H., and Watson, M.W. (2019). Introduction to Econometrics, Fourth edition, Pearson.
- Wooldridge, J.M. (2020). Introductory Econometrics: A Modern Approach. Seventh Edition, Cengage Learning.

DATE AND LOCATION

The Summer School will take place from the 24th to the 28th of June 2024 at Villa La Stella, Via Iacopone da Todi, 2 | I-50123 Florence, from 9:00 am to 5:00 pm Central European Summer Time (CEST).

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REGISTRATION FEES

The Residential Summer School fee amounts to:

Full-time Students*: € 1260.00
Full-time Ph.D. Students: € 1930.00
Academic: € 2210.00
Commercial: € 3260.00

*To be eligible for full-time student prices, participants must provide proof of their **full-time** student status for the current academic year. Our standard policy is to provide all **full-time students**, be they Undergraduates or Masters, access to our student registration rates. Part-time master and doctoral students on the other hand, who are also currently employed will however, be assigned the standard academic registration fee. Residential costs for full-time students are completely covered TStat Training through our Investing in **Young Researchers Programme**. Participation is however restricted to a maximum of 2 students.

Fees are subject to VAT (applied at the current Italian rate of 22%). However, under current EU fiscal regulations, VAT will not be applied to companies, institutions or universities, providing a valid tax registration number.

Please note that a *non-refundable deposit* of € 100.00 for students and € 250.00 for Academic and Commercial participants, is required to secure a place and is payable upon registration. The number of participants is limited to 15. Places will be allocated on a first come, first serve basis.

Course fee covers: teaching materials (copies of lecture slides, databases and routines used during the school); a temporary software licence for use throughout the sessions, valid for 30 days from the first day of the course; half board accommodation (breakfast, lunch and coffee breaks), a single room at Villa La Stella or equivalent (5 nights). Participants requiring accomodation the night of the final day of the school, are requested to contact us as soon as possible.

To maximize the usefulness of this summer school, we strongly recommend that participants bring their own laptops with them, to enable them to actively participate in the empirical sessions.

CREDITS

The workload for the course is equivalent to 32,5 hours of classwork (teaching). TStat does NOT award for this Summer School, each student will therefore need to verify with her/his own doctoral/master program to determine whether participation on the Summer School can be converted into credits and to request the recognition of credits at her/his Institution. Potential participants are therefore advise to check in advance the terms and conditions required by their academic institution regarding the attribution of credits for participantion.

Master's students and Ph.D. students participating in the summer school who need to be graded in order to receive credits MUST request in advance to sit the final exam on the 28th of June.

COURSE LEADERS

Dr Elisabetta PELLINI, Centre for Econometric Analysis, Bayes Business School (formerly Cass), London (UK).

Professor Giovanni URGA, Centre for Econometric Analysis, Bayes Business School (formerly Cass), London (UK).

REGISTRATION DEADLINE

Individuals interested in attending this summer school must return their completed registration forms by e-mail training@tstat.eu to TStat by the 1st of May 2024.

CONTACTS

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