



International Workshop

ECONOMETRICS OF THE ENERGY TRANSITION

June 5th-6th, 2024

Sala Cinema

Fondazione Eni Enrico Mattei

Corso Magenta 63

Milan, Italy

Final Program
Wednesday, 5th June 2024

13:20 – 13:50 *Registration*

13:50 – 14:00 *Opening*

- **Alessandro Lanza** (Executive Director, Fondazione Eni Enrico Mattei)
- **Matteo Manera** (Fondazione Eni Enrico Mattei, University of Milano-Bicocca)

14:00 – 15:00

Keynote Lecture

Chair: Matteo Manera (Fondazione Eni Enrico Mattei, University of Milano-Bicocca)

“Forecasting greenhouse gases, global temperatures, ocean heat content and a global sea-level rising using a multivariate VAR approach”

Jennifer Castle (University of Oxford)

15:30 – 17:30: **Session I – “Climate change impacts”**

Chair: Marzio Galeotti (Scientific Research Director, Fondazione Eni Enrico Mattei and University of Milan)

- *“Parallel PATHs: structural scenarios for environmental impacts in a Bayesian Structural GVAR model”*
Chiara Casoli (Fondazione Eni Enrico Mattei)
- *“The Manufacturing Sector in the New Era of the EU ETS”*
Fotios Kalantzis (European Investment Bank)
- *“A comprehensive Climate Index for Europe with a Multilevel Factor Model”*
Luca Pedini (Fondazione Eni Enrico Mattei)
- *“Towards a representative social cost of carbon”*
Richard Tol (University of Sussex, Vrije Universiteit)

Thursday, 6th June 2024

10:00 – 11:00 **Session II – “Finance, commodities and transition risks” - Part 1**

Chair: **Andrea Bastianin** (Fondazione Eni Enrico Mattei, University of Milan)

- *“Learning from Experts: Energy Efficiency in Residential Buildings”*
Roberto Casarin (Ca’ Foscari University of Venice)
- *“Causality, Connectedness, and Volatility Pass-through among Energy-Metal-Stock-Carbon Markets: New Evidence from the EU”*
Parisa Pakrooh (Fondazione Eni Enrico Mattei)

11:30 – 13:00: **Session II – “Finance, commodities and transition risks” - Part 2**

- *“Commodity Prices and Fiscal (Pro)Cyclicality”*
Ivan Petrella (Warwick Business School)
- *“The role of human emotions in commodity markets”*
Francesco Ravazzolo (Free University of Bozen-Bolzano, BI Norwegian Business School)
- *“External finance and corporate emissions: Distributional perspective”*
Marcin Wolski (European Investment Bank)

14:00 – 15:00: **Session III – “Energy shocks and the macroeconomy” - Part 1**

Chair: **Matteo Manera** (Fondazione Eni Enrico Mattei, University of Milano-Bicocca)

- *“Gas price shocks and the Euro area inflation”*
Massimo Ferrari Minesso (European Central Bank)
- *“Unveiling inflation: Oil Shocks, Supply Chain Pressure, and Expectations Post-COVID”*
Hilde Bjørnland (BI Norwegian Business School)

15:30 – 17:00: **Session III – “Energy shocks and the macroeconomy” - Part 2**

- *“What drives European carbon market? Macroeconomic indicators and forecasts”*
Andrea Bastianin (Fondazione Eni Enrico Mattei, University of Milan)
- *“Natural gas and the macroeconomy: not all energy shocks are alike”*
Andrea Gazzani (Bank of Italy)
- *“Energy shocks in the Euro area: disentangling the pass-through from oil and gas prices to inflation”*
Daniele Valenti (Fondazione Eni Enrico Mattei, Polytechnic of Milan)

17:00 – 17:15: *Closing*

Abstracts

Jennifer Castle and David Hendry: *“Forecasting greenhouse gases, global temperatures, ocean heat content and a global sea-level rising using a multivariate VAR approach”*

Abstract: Forecasts of key climate variables are produced using a multivariate cointegrated VAR. The system augments carbon dioxide with methane and nitrous oxide in parts per million of atmospheric CO₂ equivalents to model the effects of all major greenhouse gases (GHGs). Encompassing tests are used to establish the system model dominance over a model with radiative forcing. The model is augmented for natural variation including El Niño–Southern Oscillation and we include ice loss from cointegration between Greenland and Antarctic ice sheets plus changing albedo from the Arctic Ocean. The debate over the order of integration of the system (I(1) versus I(2) and multi-cointegration) plays little role in the forecast performance. Finally, we test the system for evidence of tipping points using a short sequence of impulse indicators to measure if large systematic one-sided 1-step-ahead forecast errors is occurring as the forecast origin advances. We propose replacing those indicators by the average of a broken linear and log-linear trend to forecast the evolution of a tipping point.

Chiara Casoli, Matteo Manera, Parisa Pakrooh and Daniele Valenti – *“Parallel PATHs: structural scenarios for environmental impacts in a Bayesian Structural GVAR model”*

Abstract: We investigate the environmental Impacts – measured as CO₂ emissions – of Population, Affluence and Technology (IPAT) for the major emitter countries at world level. In this respect, we develop a global VAR model that: i) accounts for endogenous relationships among all the IPAT variables; ii) encompasses cross-countries spillover effects; iii) embodies structural scenarios and conditional forecasting analysis to assess the impacts of the “Net Zero Emissions by 2050” policy. Our results will be crucial to quantify the role of international spillover and to evaluate alternative (“parallel”) PATHs that are compatible with a reduction in global CO₂ emissions.

Keywords: Environmental impacts, Carbon emissions, STIRPAT model, Bayesian Structural Global VAR model, conditional forecasting.

Benjamin Hattmer and **Fotios Kalantzis**: *“The Manufacturing Sector in the New Era of the EU ETS”*

Abstract: This study investigates the effects of higher ETS prices and those of changing the allocation of emission allowances in the EU Emissions Trading System (ETS) on the manufacturing sector. To do so, we first run a panel data analysis to explore the role of higher ETS prices on emission performance, investment and production price and capacity, after controlling for various factors, among other, like energy and labor costs.

Then, we run a natural experiment based on the carbon leakage status of sectors, by comparing the performance of sectors that switched from receiving free allowances to buying them in Phase IV of the ETS with those that remained unchanged. We find that higher ETS prices or the change in the carbon leakage status have a positive impact on innovation, investment, and emission reduction, while having a negligible impact on production and producer prices, which suggests that the modernisation effects are much stronger than the downsizing ones under stricter climate policy developments. Our results imply that reducing free allowances or higher ETS prices can enhance the environmental and economic resilience of the EU manufacturing sector.

Keywords: Emission Trading Scheme, Carbon leakage status, ETS prices, Manufacturing sector, Difference in difference analysis.

Chiara Casoli, **Luca Pedini**, Matteo Manera and Daniele Valenti – *“A comprehensive Climate Index for Europe with a Multilevel Factor Model”*

Abstract: In this article we propose a new climate index for Europe that considers several climate variables from the ERA-5-land database. With respect to the existing climate indices, our proposal has the advantages of using a wider amount of information. In fact, we rely on a latent factors approach, which allows us to include a higher number of climate-related variables that are usually not included. Using a Multilevel Factor Model approach, we can further distinguish between local factors, affecting individual countries, and a global factor, representing Europe as a whole. Our index is therefore useful as a climate variable for both aggregated and country-level analyses. The climate index we obtain is finally compared to some alternatives by considering different methodologies.

Keywords: European climate index, multilevel factor models, gridded climate data

Jinchi Dong, **Richard Tol** and Fangzhi Wang – *“Towards a representative social cost of carbon”*

Abstract: The majority of estimates of the social cost of carbon use preference parameters calibrated to data for North America and Europe. We here use three alternative data sets for attitudes to time and risk across the world. For two of the three, the social cost of carbon differs substantially between the global north and south. If corporate preferences are used, the social cost of carbon increases but if the preferences of the general population are used, it falls. These differences are more pronounced if we count people rather than countries.

Keywords: social cost of carbon.

Monica Billio, **Roberto Casarin**, Michele Costola and Veronica Veggente – “*Learning from Experts: Energy Efficiency in Residential Buildings*”

Abstract: Measuring and reducing energy consumption constitutes a crucial concern in public policies aimed at mitigating global warming. The real estate sector faces the challenge of enhancing building efficiency, where insights from experts play a pivotal role in the evaluation process. This research employs a machine learning approach to analyze expert opinions, seeking to extract the key determinants influencing potential residential building efficiency and establishing an efficient prediction framework. The study leverages open Energy Performance Certificate databases from two countries with distinct latitudes, namely the UK and Italy, to investigate whether enhancing energy efficiency necessitates different intervention approaches. The findings reveal the existence of non-linear relationships between efficiency and building characteristics, which cannot be captured by conventional linear modeling frameworks. By offering insights into the determinants of residential building efficiency, this study provides guidance to policymakers and stakeholders in formulating effective and sustainable strategies for energy efficiency improvement.

Keywords: Energy efficiency, Energy Performance Certificate, Machine learning, Tree-based models, big data.

Parisa Pakrooh and Matteo Manera – “*Causality, Connectedness, and Volatility Pass-through among Energy-Metal-Stock-Carbon Markets: New Evidence from the EU*”

Abstract: The EU carbon market serves as an innovative financial instrument with the primary objective of contributing to mitigate the impacts of climate change. This market demonstrates significant interconnectedness with fossil energy, precious metal, and financial markets, although limited research has focused on the causality, dependency, intensity and direction of time-varying spillover effects. This study aims to investigate the causality direction, degree of dependency structure, and volatility transmission from Brent Oil, UK Natural Gas, Rotterdam Coal, Gold, and EuroStoxx600 future prices to EU Allowances during different periods of EU market. To achieve these objectives, this paper proposes a novel methodological approach that combines the most recent econometrics methods, such as Directed Acyclic Graph analysis, C-Vine Copula models, and Time-Varying parameter Vector AutoRegressive models with Stochastic Volatility with the use of a comprehensive sample of daily data from 26 April 2005 to 31 December 2022. The major findings of this study demonstrate that causality predominantly runs from energy, metal, and financial markets to the EU carbon market. The dependency structure, although varying across different sub-periods, shows a strong relationship observed between fossil fuels, particularly coal, and CO2 market. Additionally, the EuroStoxx600 futures price index exhibits the highest dependence on EUA prices. Furthermore, the study establishes that the EU carbon market is a net receiver of shocks from all other markets, with the energy and financial markets significantly influencing volatility in EUA prices. The time-varying spillover effect is most pronounced with a one-day lag, and the duration of the spillover effects between carbon and EuroStoxx600 ranges from 3 to 15 days, gradually diminishing over time. These results have the

potential to increase the understanding of the EU carbon market and offer practical guidance for policymakers, investors, and companies involved in this domain.

Keywords: Causality direction, Dependency structure, EU-ETS, Time-varying spillover.

Federico di Pace, Luciana Juvenal and **Ivan Petrella** – “*Commodity Prices and Fiscal (Pro)Cyclicality*”

Abstract: We investigate the fiscal response to exogenous commodity price shocks in Emerging Market and Developing Economies (EMDEs), which are crucial for understanding domestic business cycles. We challenge the reliance on unconditional correlations for policy analysis, advocating for a nuanced approach that considers conditional dynamics specific to commodity shocks. We make three significant contributions: Firstly, we demonstrate that fiscal authorities in EMDEs increase spending and moderately raise taxes in response to commodity shocks, leading to a counter-cyclical fiscal stance. Secondly, our empirical findings align with the optimal policy response to export price shocks in a multi-good small open economy model. Lastly, we reveal heterogeneity in fiscal responses across countries, with stronger institutional frameworks exhibiting counter-cyclical policies, whereas weaker institutions persist with pro-cyclical approaches.

Joseph Byrne, Luigi Gifoni and **Francesco Ravazzolo** – “*The role of human emotions in commodity markets*”

Abstract: This paper explores the often under-theorised interrelation between human emotions and commodity risk within financial and macroeconomic markets. While traditional risk models focus on quantitative factors, our study delves into the psychological aspects that shape market dynamics. By exploiting information embedded in economic leading newspapers, we use emotional sentiment as a feature to detect country-specific commodity risk. Understanding how human sentiment interplays with market trends provides valuable insights for risk management strategies. Our findings contribute to a more holistic approach to risk assessment, shedding light on the human element that underlies the complexities of commodity markets. This research has practical implications for investors, policymakers, and risk analysts seeking to enhance their understanding of the nuanced factors driving commodity price movements.

Marcin Wolski – “External finance and corporate emissions: distributional perspective”

Abstract: We look into the relation between capital structure and carbon intensity of manufacturing firms, in a novel data set, which merges information from the EU Emission Trading System with firm-level financial accounts. Our main results suggest that higher financial leverage is correlated with lower firm-level emission intensity, and

that this effect can be predominantly attributed to long-term debt. We argue however that debt financing is not the panacea to improve firms' carbon intensity performance. Firstly, at excessive levels of debt, firms which further increase leverage indeed see improvement in carbon intensity but compared to other firms in the sector their carbon intensity improves at a slower pace. We further find that the low-carbon benefits of financial leverage are only meaningful for firms at higher percentiles of carbon intensity distribution. It suggests that external finance helps in green technology adoption but firms which are already carbon efficient should rather seek more innovation capital to push the carbon efficiency frontier further.

Keywords: low-carbon transition, climate change, debt finance, financial leverage, EU ETS.

Andrea Bastianin, Elisabetta Mirto, Yan Qin and Luca Rossini – *“What drives the European carbon market? Macroeconomic indicators and forecasts”*

Abstract: Putting a price on carbon – with taxes or developing carbon markets – is a widely used policy measure to achieve the target of net-zero emissions by 2050. This paper tackles the issue of producing point, direction-of-change, and density forecasts for the monthly real price of carbon within the EU Emissions Trading Scheme (EU ETS). We aim to uncover supply- and demand-side forces that can contribute to improving the prediction accuracy of models at short- and medium-term horizons. We show that a simple Bayesian Vector Autoregressive (BVAR) model, augmented with either one or two factors capturing a set of predictors affecting the price of carbon, provides substantial accuracy gains over a wide set of benchmark forecasts, including survey expectations and forecasts made available by data providers. We extend the study to verified emissions and demonstrate that, in this case, adding stochastic volatility can further improve the forecasting performance of a single-factor BVAR model. We rely on emissions and price forecasts to build market monitoring tools that track demand and price pressure in the EU ETS market. Our results are relevant for policymakers and market practitioners interested in quantifying the desired and unintended macroeconomic effects of monitoring the carbon market dynamics.

Keywords: Bayesian inference, carbon prices, climate changes, EU ETS, forecasting.

Knut Are Aastveit, **Hilde Bjørnland**, Jamie L. Cross and Helene O. Kalstad – *“Unveiling inflation: Oil Shocks, Supply Chain Pressure, and Expectations Post-COVID”*

Abstract: Following low inflation rates prior to the COVID-19 pandemic, global inflation has increased over the past years, raising questions about the underlying drivers of the inflationary pressure. In this paper, we estimate a structural VAR model to analyze to what extent oil market shocks and global supply chain pressure have been driving inflation, and the role played by inflation expectations in amplifying the effects of these shocks. Focusing on the US, the UK, the euro area and Norway, we find that both oil

market shocks and supply chain pressures have been prominent drivers of the recent inflation surge in all countries. In particular, we show that the degree of expected and actual inflation sensitivity and the associated oil price pass-through can depend on the underlying oil market shocks and global supply disruptions. Finally, we use counterfactuals to analyse the role of expected inflation in transmitting these shocks to inflation across countries.

Keywords: Oil prices, global supply chain pressure, Inflation expectations, inflation pass-through.

Jakob Fèveile Adolfsen, **Massimo Ferrari Minesso**, Jente Esther Mork and Ine Van Robays – *“Gas price shocks and the Euro area inflation”*

Abstract: This paper develops a Bayesian VAR model to identify three structural shocks driving the European gas market: demand, supply and inventory shocks. We document how gas price fluctuations have a heterogeneous pass-through to euro area prices depending on the underlying shock driving them. The pass-through is stronger and more persistent when gas prices are driven by aggregate demand or supply pressures, while inventory shocks have a weaker impact. Supply shocks, moreover, are found to pass through to all components of euro area inflation -- producer prices, wages and core inflation, which has implications for monetary policy. We finally document how the response of gas prices to shocks is non-linear and is significantly magnified in periods of low unemployment.

Keywords: Gas Price, Pass-through, Price, Euro Area.

Piergiorgio Alessandri, **Andrea Gazzani** – *“Natural gas and the macroeconomy: not all energy shocks are alike”*

Abstract: To investigate how natural gas supply shocks affect output and inflation, we construct an instrument using daily news on the European gas market over 2010-2022 and employ it within a VAR model. We find that negative supply shocks are stagflationary and that their effects materialize over far longer horizons than those of oil supply shocks, with peaks (troughs) in core inflation (industrial production) that follow the shock by two years or more. This pattern is consistent with the structural features of the gas market, and it suggests that European economies are still grappling with the shocks occurred in 2021-22.

Keywords: Natural Gas Prices, Inflation, Narrative Identification, Bayesian VAR.

Chiara Casoli, Matteo Manera and **Daniele Valenti** – *“Energy shocks in the Euro area: disentangling the pass-through from oil and gas prices to inflation”*

Abstract: We develop a Bayesian Structural VAR model to study the relationship between different energy shocks and inflation dynamics in Europe. Specifically, we model the endogenous transmission from shocks identified by the global market of crude oil and the European natural gas market to two target macroeconomic variables, i.e. inflation expectations and realized headline inflation rate. Our results demonstrate that, since the post-pandemic recovery, inflation in the Euro area is mostly driven by energy price shocks and aggregate supply factors. In particular, the high peaks of the Eurozone inflation are mostly associated with natural gas supply shocks.

Keywords: Bayesian Structural VARs, Inflation, Energy shocks, Oil and gas markets.