

## Introduction

The pricing of electricity forwards is inherently complex: because electricity cannot yet be economically stored at scale, **the standard cost-of-carry model that connects forward prices to spot prices in commodity markets does not apply directly**. Instead, electricity forward prices are typically modelled as a function of expected spot prices and a risk premium. Variable renewable energy (VRE) producers are increasingly looking beyond spot markets toward forward markets as a means of managing revenue risk. **As VRE producers hedge their output variability in forward markets, they alter both forward prices and risk premiums**, complicating the hedging decisions made between forward and spot trading. Growing VRE market shares amplify forward price volatility, as meteorological uncertainty propagates into longer-dated contracts. This research aims to quantify how weather prediction uncertainty propagates into the risk premiums.

## Theoretical Background

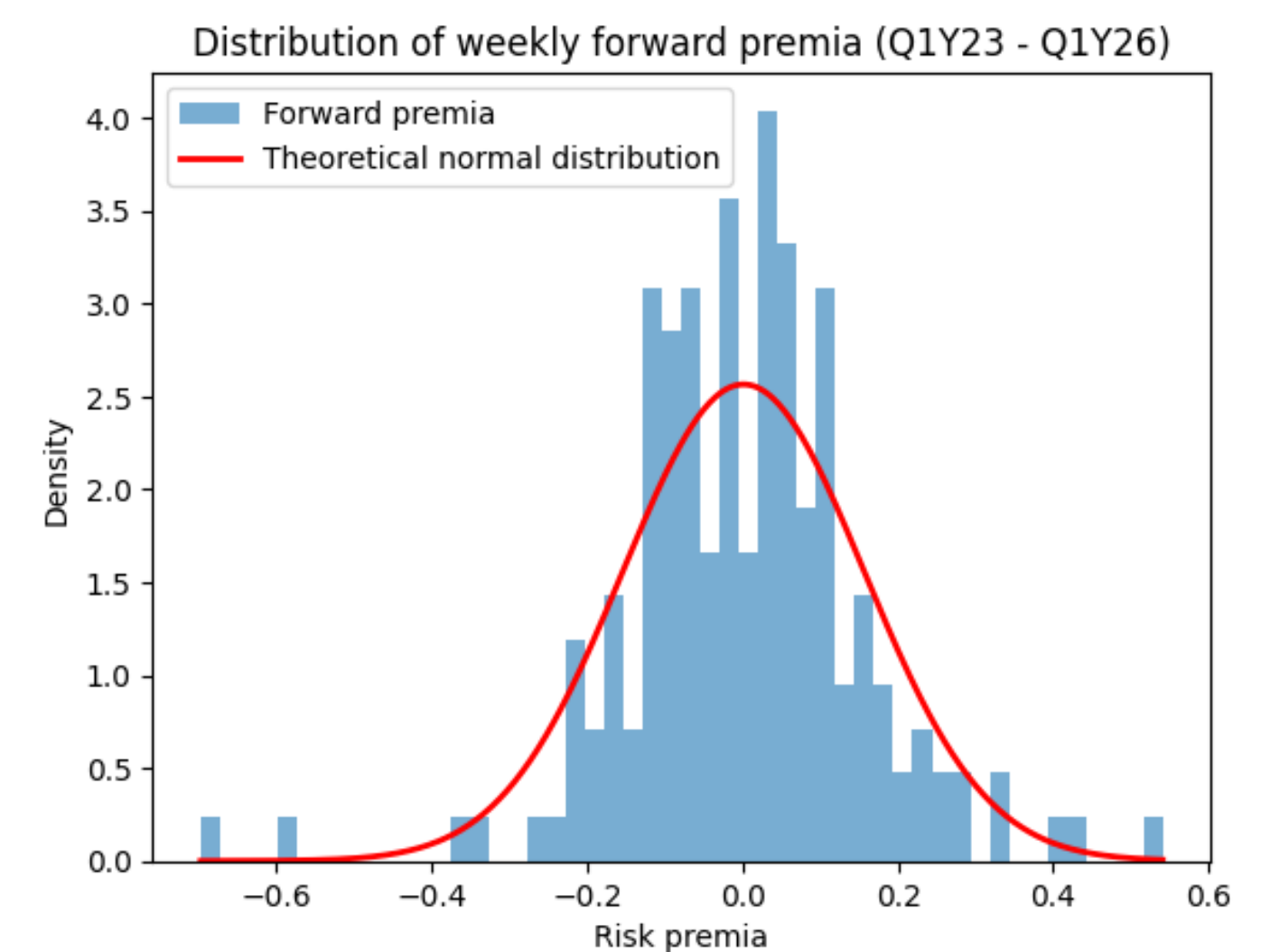
The expanding VRE capacity is expected to reshape demand profiles significantly, generating episodes of negative residual load, consequently eroding wholesale electricity prices, and placing considerable strain on baseload generation. Growing **VRE market shares amplify forward price volatility**, as uncertainty originating in spot markets propagates into longer-dated contracts. The price **effects of renewable output deviations are also asymmetric**: supply scarcity tends to produce sharper upward price spikes than surplus causes downward ones, generating a negative skewness effect that weighs on the forward premium. Active forward participation by VRE appears to change how risk is allocated across wholesale electricity markets. As weather uncertainty becomes a structural rather than incidental feature of power markets, there is a growing need for valuation frameworks that explicitly incorporate forecast uncertainty into the valuation of forward contracts and risk premiums.

## Methods

**This research examines to what extent meteorological forecast uncertainty determines the risk premium embedded in forward contracts**. In doing so, it aims to equip market participants with a tractable method for inferring risk premiums from observable forward prices. The proposed framework proceeds in three stages. First, a forward contract price, approximated as the expectation of future spot prices, is estimated using a set of explanatory market and meteorological variables. Second, the ECMWF ensemble forecast (50 members) is used to propagate weather uncertainty through the model, producing a distribution of forward price estimates; the shape and skewness of this distribution are then used to infer the direction and magnitude of the risk premium embedded in the contract. Third, the financial risk associated with holding the contract under this uncertainty is quantified using Expected Shortfall (CVaR), providing a coherent, tail-sensitive measure of downside exposure.

## References

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The weekly forward premia displayed above are the so-called ex-post premia, computed for the Polish market as the difference between the realized day-ahead price and the volume-weighted average price (VWAP) of the corresponding weekly forward contract, measured after contract expiry.

