Improving Natural Gas Demand Forecasting Through the Reconciliation of Incoherent Data Hierarchies

Colin O . Quinn

Richard J. Povinelli

Abstract:

Time series reconciliation involves aligning a set of incoherent, independently generated base forecasts according to a predefined set of linear constraints. These linear constraints are typically based on inherent characteristics of the hierarchy being reconciled. If significant incoherence is present in the in-sample training data, out-of-sample forecasts may be reconciled under inaccurate constraints. This study investigates the effectiveness of applying a weighted reconciliation preprocessing technique to natural gas consumption data with significant in-sample incoherence prior to calculating the out-of-sample base forecast.

Natural gas consumption in a single service area is often measured by multiple time series spanning various temporal resolutions and geographical regions. While these time series lack coherence when organized hierarchically, we demonstrate that relevant information can still be extracted from gas consumption data to enhance out-of-sample forecast reconciliation accuracy. Incoherence in consumption data occurs when one consumption signal does not align with others; for instance, an hourly consumption series not summing to its daily series counterpart. Adjustments to the incoherent consumption data are made by comparing aggregated versions of lower hierarchical levels to their higher counterparts, or vice versa.

Historical heating season hierarchies are used to calculate a distribution for identifying appropriate reconciliation constraints for the out-of-sample forecast. A new hierarchical node is introduced to contain the preprocessing “coherency error”, addressing the industry's "Lost and Unaccounted (LAUF)" gas found in the training data. Error from both the aggregated-consumption comparison and LAUF is propagated throughout the in-sample consumption observations using Minimum Trace Reconciliation.

Our in-sample reconciliation preprocessing technique is tested across three temperature-sensitive gas operating areas and results in a 9.6% reduction in MAPE in the included case studies. Through this analysis, we underscore the advantages of adopting hierarchical time series reconciliation techniques in gas demand forecasting and provide insights into adaptability of such techniques to incoherent data sets.