

Analysing the relationship between district heating demand and weather conditions through conditional mixture copula

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Abstract Efficient energy production and distribution systems are urgently needed to reduce world climate change. Modern district heating systems play a crucial role in this context since they are energy distribution services that exploit renewable sources and use smart grids for any heat request in the urban area. To enhance heat production schedule, in-depth knowledge of thermal energy demand, which is mainly affected by weather conditions, is essential. We hence propose a mixture copula-based approach to investigate the complex relationship between meteorological variables, such as outdoor temperature and solar radiation, and thermal energy demand in the district heating system of the Italian city Bozen-Bolzano. We analyse data collected from 2014 to 2017, and estimate copulas after removing serial dependence in each time series using autoregressive integrated moving average models. A finite mixture of heterogeneous parametric copulas to generate dependence structures not expressible by the existing models is specified. Precisely, we selected a mixture of an unstructured Student-t copula and a flipped Clayton copula, that makes it possible to differentiate the magnitude of dependence in each tail and to exhibit both heavy tail and asymmetric dependence. We derive the conditional copula-based probability function of thermal energy demand given meteorological variables, and provide useful insight on efficiently planning the heat production and distribution.

Key words: Conditional probability, Copula function, Flipped copula, Mixture copula, Thermal energy demand

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