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On The Interpretation of Vector Autoregressive Models

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On The Interpretation of Vector Autoregressive Models

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Abstract

Understanding dynamic processes—whether in psychology, economics, or neuroscience—often requires models that can capture both the evolution of variables over time and the intricate, sometimes instantaneous, interactions between them. Traditionally, the discrete-time vector autoregression (VAR) model has been the workhorse for analyzing time series data, capturing how past values influence current outcomes. The conventional discrete-time VAR is prized for its simplicity and ease of estimation, making it a popular choice for forecasting and exploratory analysis. However, its inability to disentangle mixed effects or account for instantaneous interactions has spurred interest in more refined approaches. SVAR models address this limitation by imposing identification restrictions that allow for the separation of instantaneous and lagged effects, thereby offering a closer approximation to the causal dynamics that may be present in an underlying continuous-time system.

More recently, continuous-time VAR (CTVAR) models have emerged as a promising alternative, providing an even more natural representation of systems that evolve continuously, albeit observed only at discrete intervals. Continuous-time VAR models directly model the underlying process as evolving continuously over time. This approach is particularly appealing when the data sampling rate is insufficient to capture fast-acting influences adequately. CTVAR not only offers a conceptual match to the true dynamics of many natural systems and clearer causal interpretations, but also presents distinct estimation challenges and opportunities.

Previous studies by Demeshko et al. (2015) have shown the mathematical transformations between VAR, SVAR, and CTVAR. In theory, one can obtain the parameter values of one version of the VAR model by using the set of parameter estimates of another VAR variant from a given software. Interestingly, a different VAR model represents an alternative dynamic process, carrying a distinct interpretation. However, few studies fit empirical data using different VAR models provided by corresponding software. Therefore, there is a lack of knowledge about whether the empirical result of an alternative VAR model would match the theoretical parameters from model transformation under an empirical setting; further, how would interpretations from the alternative result change, especially from a causal inference perspective.

In this paper, we systematically compare the three representations—regular VAR, SVAR, and CTVAR—with a dual focus on their interpretation and estimation performance in existing software. We review the relevant software implementations that support these methodologies and conduct both simulation studies and empirical analyses drawn from psychological data. We are particularly interested in investigating whether the causal interpretation from the results will differ as a result of model choice. Our goal is to provide a comprehensive evaluation that not only highlights the strengths and limitations of each approach but also offers practical guidance on selecting the most appropriate modeling framework based on research objectives, data characteristics, and theoretical considerations. Through this comparative study, we aim to contribute

to the methodological toolbox available to researchers seeking to unravel the complex, dynamic interplay of variables that characterize many real-world systems.

Keywords

Time Series Analysis, Vector Autoregressive

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