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Approximate Sampling Distributions of the Parameter Estimators in the AR(1)-Model

We consider the first order auto-regressive model defined by $X_{i+1} = \rho X_i + \epsilon_{i+1}$. Based on a fully analytical approach, we demonstrate how to obtain the first four moments of some well-known estimators of ρ. This enables us to utilize the Edgeworth series to approximate the corresponding sampling distributions, which vastly improves that of the central limit theorem. More importantly, the resulting approximate sampling distributions perform very well even when the sample size is relatively small. In the case of the maximum likelihood estimator $\hat{\rho}_M$, we further show how this technique can be extended to higher order auto-regressive models.