Article

Asymptotic Theory for Cointegration Analysis When the Cointegration Rank Is Deficient

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Abstract: We consider cointegration tests in the situation where the cointegration rank is deficient. This situation is of interest in finite sample analysis and in relation to recent work on identification robust cointegration inference. We derive asymptotic theory for tests for cointegration rank and for hypotheses on the cointegrating vectors. The limiting distributions are tabulated. An application to US treasury yields series is given.

Keywords: cointegration; rank deficiency; weak identification

JEL Classification: C32

1. Introduction

Determination of the cointegration rank is an important part of analyzing the cointegrated vector autoregressive model in the framework of Johansen (1988, 1991, 1995), Johansen and Juselius (1990), and Juselius (2006). We consider the rank deficient case where the cointegration rank of the data generating process is smaller than the rank used in the statistical analysis. In that case, the data generating process has more unit roots than the number of unit roots imposed in the statistical analysis and the usual asymptotic theory fails. We provide asymptotic theory for cointegration rank tests and tests on cointegration vectors along with simulated tables of the asymptotic distributions.

Cointegration analysis is conducted in three steps. First, the specification of the model is checked. Second, the rank is determined using a sequential procedure using Dickey-Fuller type distributions. Third, the cointegrating vectors are estimated and restrictions can be tested using standard inference. Asymptotic theory shows that estimated rank is consistent in the sense that the probability that the estimated rank is not equal to the true rank equals the size of tests, whereas the probability that the estimated rank is too small vanishes, see Johansen (1992, 1995) and Paruolo (2001). Hence, the rank deficiency problem does not arise in the asymptotic analysis.

In practice, rank deficiency matters in two ways. The asymptotic theory often suffers from considerable finite sample distortion. Further, if an investigator wants to focus on the inference on the cointegrating relations then problems can arise if the rank is taken as known when in fact it is deficient. These problems mirror those of instrumental variable estimation with weak instruments, see Mavroeidis et al. (2014).

When conducting inference on the cointegrating vector under near rank deficiency the parameters are weakly identified. At the extreme when testing on the cointegrating vector in the case of a deficient rank the model is mis-specified. This problem arises in cointegration as well as in instrumental variable estimation. In both cases maximum likelihood is conducted using reduced rank regression. The weak identification problem has attracted considerable attention in the instrumental variable literature, see for instance Mavroeidis et al. (2014). Khalaf and Urga (2014) discussed the weak

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