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TIME-SERIES-BASED ECONOMETRICS

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Since the influential work by Nelson and Plosser (1982) and Engle and Granger (1987), many new and exciting developments have been made in the analysis of time series involving autoregressive unit roots. Hatanaka (1996; hereafter HT) reviewed the literature on unit roots and cointegration up to 1994 and provided new perspectives on this research area.

There are some recent monographs and review articles that summarize the research results in the area of unit roots and cointegration (see, e.g., Banerjee, Dolado, Galbraith, and Hendry, 1993; Phillips, 1997; Stock, 1995). Though HT was written with the same purpose as these monographs and review articles, HT has some distinctive features that are not necessarily shared by other books and articles. First, HT tries to relate the concepts of unit roots and cointegration to economic theories and introduces some economic theories that are relevant to the concepts of unit roots and cointegration (see Chapters 1, 12, and 14 of HT). Second, HT introduces the Bayesian analysis of unit roots and provides interesting and useful comparisons of the classical and Bayesian analyses. Though the Bayesian analysis takes up only one chapter (Chapter 10), it will be a good starting point for those who wish to study the accomplishments of the Bayesian approach to unit roots over the past few years. Third, HT does not omit technical details in most instances. This will be regarded as either an advantage or a disadvantage depending on one's perspective. But at least to the reader who wishes to study econometric theories for unit roots and cointegration, HT will be a useful reference.

As for the contents of HT, Part I introduces the concept of stochastic trend, tests for the nulls of stationarity and a unit root, asymptotic theory for the unit root process, a method for synthesizing results from unit root and stationarity tests, and the Bayesian approach to the presence of a unit root. Some of these topics are standard and can also be found in other books and review articles. But detailed test derivations of stationarity tests and the use of *p*-values for synthesizing test results are hard to find elsewhere except in original papers. In particular, using *p*-values for synthesizing test results seems to be an interesting idea and requires further investigation.

However, Part I also has room for improvement. First, there are many tests for the nulls of a unit root and stationarity (e.g., Phillips and Perron, 1988; Kwiatkowski, Phillips, Schmidt, and Shin, 1992) that employ the nonparametric long-

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run variance estimates. But HT does not discuss these tests in detail. This is unfortunate because many empirical researchers have used these tests. Second, the finite-sample power of unit root tests has been an important concern to both empirical researchers and theorists. Out of this concern, researchers have endeavored to develop unit root tests that perform better than the Dickey–Fuller tests in finite samples. An important test that belongs to this category is the augmented Dickey–Fuller test with GLS detrending introduced in Elliott, Rothenberg, and Stock (1996). But it seems that HT allocated too much space for the augmented Dickey–Fuller tests, thereby ignoring potentially more useful tests, including the Elliott–Rothenberg–Stock test. Third, there are many tests for the null of stationarity other than Saikkonen and Luukkonen (1989) (e.g., Arellano and Pantula, 1990; Choi, 1994; Kwiatkowski et al., 1992; Tsay, 1993, etc.), but these are not even mentioned in HT. Fourth, Part I seems a bit disorganized. For example, tests and their asymptotic distributions are treated in separate chapters, which makes it hard to follow them. Notwithstanding these remarks, Part I is an excellent introduction to econometrics of unit roots and is recommended to advanced graduate students and professional researchers for reading. It provides a balanced overview of the literature on unit roots and introduces key techniques that are required to understand the major developments in this research area.

Part II introduces the concept of cointegration, asymptotic theories on cointegrating regressions, inference on dynamic econometric models, and vector error correction models. No doubt, these topics are essential ingredients for understanding cointegration analysis. HT provides step-by-step discussion on these topics and, whenever necessary, explains technical details to help the reader understand theoretical aspects of cointegration analysis. Furthermore, Professor Hatanaka compares the various methods in cointegration analyses in light of his long experience and gives useful guidance to empirical researchers as to modeling and inference in cointegration analysis.

However, there seems to be a few practically and theoretically important topics that, if included in Part II, might make HT more useful. First, relating the cointegrating regression and the traditional simultaneous equations model (SEM) seems to be an important topic that is neglected in HT. The SEM has been one of the most prevalent modeling strategies since the early 1950's, and the cointegrating regression is a relatively new tool still quite vigorously being developed. How these old and new methods can be combined is a topic that needs further investigation. In relation to this, Saikkonen (1993) discussed how to estimate the cointegrated SEM. See also Phillips and Loretan (1991), which relates the SEM and cointegrating regressions. Second, in light of the widespread use of VAR for policy analysis and various empirical findings of cointegrating relationships among economic variables, explaining how to perform VAR analysis for cointegrated variables would be quite useful for empirical researchers. For this, Lütkepohl and Reimers (1992) may be used as a reference. Third, regressions with nearly integrated regressor are of practical importance because many economic time series appear to be nearly integrated. Cavanagh, Elliott, and Stock (1995) suggest an approach with regard to this problem. But even without the inclusion of these

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topics and others that are not mentioned, Part II of HT is an excellent introduction to cointegration that is recommended reading for advanced graduate students and researchers. It will provide sufficient background knowledge for understanding most of the articles in the area of cointegration.

HT can serve as a text for a graduate course on nonstationary time series if it is complemented by some articles. According to my own experience and preference, the following sequence based on HT may be adequate for a one-semester course on nonstationary time series. First of all, Chapters 1 and 2 need to be covered as an introduction to unit root and cointegration. Next, the Dickey–Fuller tests introduced in Chapters 5 and 7 need to be discussed, because these tests are often used in empirical applications. Additionally, introducing more recent tests such as the Phillips–Perron and Elliott–Rothenberg–Stock tests would also be helpful. Understanding asymptotics for all these tests requires nonstandard asymptotic results, which are covered in Chapters 4 and 6. These two chapters rest on the functional central limit theorem, which most economics students find hard to follow. My own personal experience indicates that Phillips and Solo (1992) is quite helpful at this point: it provides an intuitive and understandable approach to the functional central limit theorem for linear processes that is general enough for most economic applications. After dealing with unit root tests, it would be appropriate to discuss tests for the null of stationarity, which are covered in Chapter 3. But as mentioned previously, it should be pointed out that there are many stationarity tests not introduced in Chapter 3.

Once students are taught econometrics of unit roots, a natural topic to follow is cointegration. Chapters 11 and 12 provide a detailed introduction to cointegration and are recommended reading. Because standard theories do not apply to OLS regressions involving cointegrated economic variables, the asymptotic theories for cointegrating regressions introduced in Chapter 13 are particularly useful. But unfortunately, this chapter does not discuss recent efficient methods for estimating cointegrating regressions. Such methods are well summarized in Phillips and Loretan (1991). Factually, what one should do before estimating cointegrating relations is to find whether or not there are cointegrating relations among the variables of interest. In this sense, testing for cointegration should precede estimating cointegrating relations in empirical research. But understanding cointegration tests requires asymptotic theories discussed in Chapter 13, and, therefore, introducing cointegration tests after covering Chapter 13 would make the course easier for students. Because it seems that Johansen's (1988) tests are most often used in practice, it is sensible to treat Chapter 15 in detail. But it should be emphasized that the Johansen VAR does not provide structural parameter estimates unless identification conditions are imposed on VAR parameter matrices. Teaching the topics mentioned so far would be sufficient to take up one semester. But if there is extra time, it would be useful to discuss the Bayesian analysis in Chapter 10 and the Hendry model in Chapter 14.

In summary, HT is an excellent review on unit roots and cointegration and can serve as a useful textbook for a nonstationary time series course particularly designed for Ph.D. students in economics.

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