Analysis of Integrated and Cointegrated Time Series with R
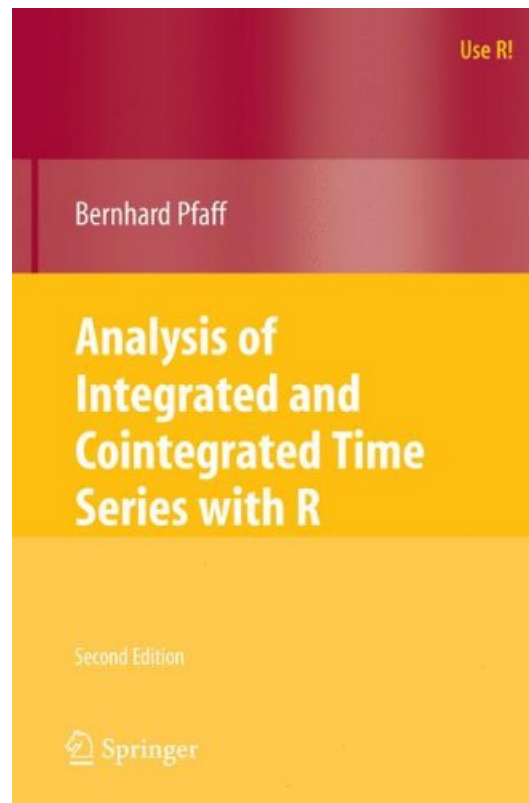## Book Summary

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Abstract

The purpose of this document is to summarize the main points of the book "Analysis of Integrated and Cointegrated Time Series with R".

There are broadly three aspects that one needs to spend time on, while learning about any statistical model.

1. Intuition behind a model in describing a problem/phenomenon/scenario.
2. Nitty gritty of the model : The assumptions of the model, its functional form, the math behind parameter estimation, the way to plot the data and perform diagnostics, do forecasting based on the model and do structural analysis with the model.
3. Simulating data from a known data generating process and code up the functions to check your understanding.

This book addresses the third aspect mentioned above and is a valuable text in equipping the reader in DOING econometric analysis. Given the vast subject of econometrics, the author has picked two specific areas, i.e. unit root testing and cointegration and has dealt with the software needed to perform related tasks. The author is not merely a spectator but has actively contributed to many `R` packages and instead of merely submitted a vignette on CRAN, he has taken pains to write an entire book about it. Clearly this book is more than a manual describing a few packages.

There are three parts to the book. The first part deals with the math behind the models. Obviously it is more like a quick reference to all the topics that are dealt with the other parts of the book.

Part I of the book is titled "Theoretical concepts" but it does not go in to the gory details of the models. All it does is to say: *Here is the functional form of the model, here is the code and here is some commentary on the same.* However I did not fell that it is a cookbook kind of content. The commentary adequately captures the essence of the described models.

The first chapter deals with univariate stationary series. AR(p), MA(q), ARMA(p,q) models are described and the relevant code is shown to so that reader can simulate, plot, estimate, do diagnostics, and do forecasting. Since these activities are a recurring theme through out the book, I will refer to them as **SPEDFS** (**S**imulate, **P**lot, **E**stimate, **D**iagnostics, **F**orecast, **S**tructural analysis). Towards the end of the chapter, the Box-Jenkins approach which is usually called *ocular econometrics* is introduced.

The second chapter deals with VAR(p) and SVAR(p) models. Before VAR models came in to prominence, the usual way to deal with multivariate time series was to model each of the individual component with a Box-Jenkins kind of an approach and then assemble all of the components in to one, obviously ignoring the correlations between the components. VAR was the first kind of framework that dealt with all the time series at once. The chapter does the usual **SPEDFS**. The author has written a fantastic package `vars` that covers all the aspects of VAR model. Obviously it goes with out saying that the content makes sense only if you are thorough with the intuition behind the models and the nitty gritty of the model. The good part about this book is that there are extensive references given for various results that are used in **SPEDFS** activities. One can use a command from a package and crunch out any statistic, let's say, a model criterion such as FPE(Final Prediction Error) but I think it is equally important to know the actual math behind it. How much of depth that one needs to go in to such things ? is always a difficult question to answer. In anycase all the references mentioned in the book are priceless.

The third chapter deals with non-stationary series and in particular talks about unit root testing. Well, the literature on unit root testing is enormous. There is a need to test whether a series is integrated of order d for various reasons. If you are a trader and you infer that a price process is $I(d), d \geq 1$, you will not trade that instrument per se. On the other hand if it is $I(0)$, there is a chance to make money. Unit root testing

has gone through several forms and the one method that has kind of reached a consensus is mentioned as a detailed flow chart in the book. There might be a misconception among some, in thinking that a series can be tested for the presence of unit root with some command from some package. This chapter tries to clear that misconception by showing that one needs to think about various aspects like the presence of intercept, presence of a trend, presence of lagged variables etc. in performing a unit root test. Even though a flow chart is provided that gives the testing sequence for unit roots, a curious first timer would want to go through the math behind the inference. For example, given that there is a time trend in the data, why are the usual asymptotics valid?. This has got to do the with the rate of convergence of the variable. Only when such things are clear in one's mind, flow chart like the one given in the book becomes a valuable anchor point for thinking about unit root testing.

The fourth chapter deals with cointegration. It introduces the topic by showing presence of spurious correlation between integrated time series. The connection between a cointegrated system and a VECM model is shown via code and some examples. The two methods for doing cointegration analysis, Engle-Granger and Johansen procedure are described. The functional form and specific results are given for both the methods.

Part II of the book deals with the practical aspects of 'Unit Root testing'. The fifth chapter covers the following tests

1. Dickey-Fuller Test.
2. Phillips-Perron Test.
3. Elliott-Rothenberg-Stock Test.
4. Schmidt-Phillips Test.
5. Kwiatkowski-Phillips-Schmidt-Shin Test.

The first four tests are the ones where the null hyothesis is that the series is non-stationary and alternate hypothesis is that the series is stationary. The last test, KPSS has the null and alternate reversed. It is usually suggested that at least one of the first four tests and the fifth test be done on a series before you can reasonably stamp the series as stationary or non stationary. The sixth chapter is an advanced topic on unit root testing and deals with the issues of structural shifts and seasonal unit roots.

Part III of the book deals with cointegrated series. The seventh chapter deals with the cointegration analysis of single equation. Specific examples are taken from the econometric literature and **SPEDFS** activities are shown. The two procedures dealt in this chapter are Engle Granger method and Phillips-Ouliaris method. As has become the standard practice of the reproducible research guidelines, the code and the results are shown as part of the chapter and hence one can follow the commentary easily. The last chapter of the book deals with Johansen procedure. **SPEDFS** for VECM and SVECM are discussed.

Takeaway

The book is a valuable companion for any book that deals with econometric models. The fact that the author has contributed to some of the packages mentioned in the book makes the book all the more useful as you can glean very specific details of the functions and classes that would be hard to obtain from the vignettes and package reference manuals.