

the variance-covariance matrix of the errors is completely known, which is never true in practice. It is possible to give a more detailed treatment of asymptotic theory and its usefulness without diving into measure theory and regularity conditions. But the book covers the central limit theorem (CLT) only in the Appendix of Chapter 2. The proof of the CLT belongs in the Appendix, but a discussion of it should be more prominent.

A second example of the book's shortcomings is in the motivation and presentation of the F statistic. The F statistic first appears in Chapter 4, where it is introduced without any motivation. Where does that formula come from? The answer arrives in Chapter 7 within the context of Wald, LM, and LR tests. The F statistic is revisited as an alternative to the Wald, LM, and LR tests, when in fact it is proportional to the Wald test! No mention is ever made that the numerator of the F statistic appears again and again in the derivation of the Wald, LM, and LR tests. Making these kinds of links is important for conveying understanding to students.

The bottom line is this. There is definitely a useful role for an introductory graduate econometrics text that is less technical and more accessible to students who do not have extensive undergraduate econometrics background. It is essential that such a text avoid being purely empirical and cookbook in style. Econometrics represents a step in that direction, but further steps are needed, including some more careful editing.

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Forecasting: Methods and Applications (3rd Ed.).

Spyros MAKRIDAKIS, Steven C. WHEELWRIGHT, and Rob J. HYNDMAN. New York: Wiley, 1998. ISBN 0-471-53233-9. xiv + 642 pp. \$87.95.

Elements of Forecasting.

Francis X. DIEBOLD. Cincinnati, OH: South-Western College Publishing, 1998. ISBN 0-538-86244-0. xiii + 392 pp. \$76.95.

These two textbooks are aimed at identical audiences: (advanced) undergraduate- or masters-level business students who have an interest in or will be using forecasting techniques as part of their jobs. The book by Makridakis Wheelwright and Hyndman (MWH) is in its third edition, whereas that of Diebold (DB) is a newcomer.

Both books review the major highlights of business forecasting from a modeling and organizational perspective. Both intentionally leave aside theoretical developments and concentrate on practical aspects. There is a great deal of overlap between the two books and one should consider buying one or the other, but not both. Here I outline the material covered in both books first, then provide by individual critiques and a discussion of unique material presented in each.

Both books assume very little background knowledge of the student. However, at least one prior course in statistics would benefit the student greatly. DB has more introductory material than MWH, such as explanations of means and standard deviations. Both books present smoothing methods, although here (and most everywhere else) MWH's explanations are of greater depth and clarity. Regression techniques for forecasting are covered, as are model and variable selection and testing. Of course, both books cover ARIMA modeling in some detail. DB builds up to a full ARIMA model more slowly, taking several chapters. MWH succinctly covers ARIMA and seasonal ARIMA. Both do an adequate job with standard forecasting graphics (such as ACF plots), although DB goes further (but has some problems). Neural nets are mentioned in both texts, with MWH giving the fuller treatment. The interesting topic of ex-post forecast performance is also taken up by both books, with some unique twists

given by each. Both texts do a nice job of detailing the organizational difficulties and practicalities of business forecasting (for one thing, telling the student to keep in mind that the goal of the forecast is to aid decision making, not to overwhelm someone with clever mathematical models). Finally, both texts present numerous practical homework problems, although MWH has many more. DB has an inordinate number of problems whose only task is to "discuss" (making these difficult to grade).

To highlight the differences, DB has additional material on forecast graphics, and a more extensive discussion of unit roots and Dickey-Fuller tests. It also gives more space to ARCH and GARCH models, increasingly important tools that are only mentioned in MWH. DB includes a fuller discussion of forecast accuracy measures, devoting an entire chapter to this important topic. (After all, if a forecast is to be used in a decision it is a good idea to know how well it has performed.) This is where DB is at its best (no doubt because the author has done original research in this area).

MWH covers more topics than DB, such as an extensive overview of decomposition methods including the census X-12-ARIMA, Loess, and STL techniques. It also provides a fuller explanation of regression techniques, including multicollinearity, econometric models, multiple regression, regression with ARIMA errors, dynamic regression, and even nonparametric local regression. It presents sections on stationarity and Portmanteau tests. MWH also includes sections on intervention analysis, state-space models, nonlinear models (other than neural nets), and multivariate autoregressive models. A chapter is devoted to the special difficulties faced in long-range forecasting, and a nice chapter covers judgmental forecasting, including a discussion of how to combine judgmental and statistical forecasts. Finally, an entire chapter is devoted to the results from the M competitions. (This is not surprising, since Makridakis arranged these; for those unaware of these competitions, they were an organized effort to investigate how well various time series methods perform in practice.)

DB has many of the typical flaws of a first edition, which sometimes make the book difficult to follow. For example, there are a number of typos, some of which could be misleading to students. There are also misinterpretations that should have been caught. For example, on page 25 adjusted R^2 is said to compensate for the possible overfitting caused "(when) a variety of right hand-side variables are tried and the 'best model' is selected."

Two stylistic criticisms are the choice of font used for the equations and the overuse of footnotes. The eye-straining mathematical font is reminiscent of that found in some commercial word-processing programs. At times, it is confusing or impossible to understand or interpret the given equation. (On p. 22, for example, the reader cannot tell whether the $T - 1$ belongs inside or outside of the radical sign in the definition of sample standard deviation.) The footnotes interrupt the flow of reading, and it is not always clear why the information in them is in a note rather than included in the main text. Moreover, the author often repeats himself in the footnotes (and in the text), giving the sense that the book was not subjected to close editing. The overall readability and organization of the text give the same feeling.

A major criticism is that DB often introduces terms and phrases without definition or explanation. On page 163, the reader is told that all roots of a certain polynomial should be "inside the unit circle." The reader never learns what a unit circle is and how a root might lie there (recall that the intended audience for this book is business students). On page 197, the operator P is used without explanation. The experienced reader will understand through the context that P is meant as a projection operator, but the uninitiated might easily confuse it with a probability statement. Later, on page 296, another use for P is given (to indicate a polynomial). Finally, on page 331, in the context of introducing neural nets, the "squashing function" (normally called the activation function) is introduced but never explained (neither explained is the new and odd terminology).

In its favor, DB is the first book I have seen with an entire chapter devoted to the important area of forecasting graphics. The author's inspiration is drawn mainly from the works by Tufte. DB also brings in the use of cumsum charts for regression model parameters. However, one is left wondering why the author did not take his own advice, because the book's later half contains more than a dozen examples of less than inspirational graphics. Just to cite one example, on page 138 the reader is treated to the ACF and PACF of a white noise process (to imagine what this looks like, draw a graph with nothing on it). This phenomena could have better

explained through words than through pictures. And several times (e.g., p. 238), he plots a historical time series and forecast on one figure, followed immediately by an absolutely identical figure but with the inclusion of the realizations plotted next to the forecasts. These could have all been collapsed to one figure. DB does include a disk containing all of the data for the examples in the book.

MWH is a comprehensive overview of the field of practical business forecasting. As this book is in its third edition, most typos have been eliminated, and the flow is well designed for a textbook. Like DB, it provides data, but in the form of a web site instead of a disk. There are some minor flaws, but nothing that would prove especially problematic for a student. Most mistakes are confined to using terms without explanation (e.g., on p. 280, C_p and AIC are used without definition, although their purpose is clear, and on p. 210, \hat{a} is included with no explanation). Something that does not actually qualify as a problem is the chapter on long-range forecasting. MWH offers some interesting insights, mainly suggesting that the "usual" methodologies do not work well when forecasting for the long term. It is interesting that long-range time series data are just data, so that the standard methodologies should work. (After all, an ARMA model cannot "sense" the time periods involved.) Why they do not, of course, is that the standard assumptions (like stationarity) are no longer valid for the long term. This should emphasize to the student that all time series models are only approximations and not explanatory models. It should also give the student pause when applying short-term models, suggesting that the results are not necessarily to be trusted. Perhaps lost on the student is that most long-range forecasts are pure speculation (including some curious forecasts provided by MWH itself on pp. 474–476). Anyone doubting this should take note of William Sherden's new book (Sherden 1998) reviewing the business of economic forecasting, which argues that most business and economic forecasts are of little or no value.

To continue the discussion of long-range forecasts, MWH includes a chapter on judgmental forecasting and adjustments that provides an excellent review of all that can go wrong when human biases influence forecasts. And, as mentioned earlier, MWH includes an entire chapter on results from M competitions. Not much surprising here, but this is a great chapter to enable a student to put all previously learned theory into perspective. The student may be shocked to learn that the more complex methods (like ARIMA models) are often outperformed by simple models (like smoothing). It is fascinating that, although the research community is well aware of these facts, this has not slowed down the effort expended building newer and more complex models with no real evidence that performance is improving.

MWH does not devote much material to unit root tests, which is surprising considering the inordinate amount of time and research that econometricians devote to this topic. MWH does a nice job building and explaining in simple language the complete seasonal ARIMA model, a technique that will surely find practical use.

Overall, *Forecasting: Methods and Applications* is a mature text with thorough coverage of essential and important techniques, contains a good mix of problem sets, and should serve well as a textbook. *Elements of Forecasting* is novel and interesting because of the new ideas in graphics and practical advice that it presents.

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Time Series, Unit Roots, and Cointegration.

Phoebus DHRYMES. San Diego: Academic Press, 1997. ISBN 0-12-214695-6. xiv + 524 pp. \$89.95.

Unit root tests and cointegration have been two of the most heavily researched topics in time series since the work of Dickey and Fuller (1979, 1981) and Engle and Granger (1987). Because of the importance of these topics in theory and practice, recent time series and econometrics books

have begun to cover these issues. Unfortunately, most books consider these issues only briefly. As research on unit root tests and cointegration reaches maturity, books devoted exclusively to these two topics are now being published. *Time Series, Unit Roots, and Cointegration* is one such book (with more emphasis on cointegration than unit root tests).

Other books cover unit roots and cointegration extensively (Hamilton 1994; Reinsel 1997). One of the distinctive features of Dhrymes' book is its emphasis on theoretical development and probabilistic foundations. In its theoretical development, Dhrymes focuses on a narrower class of nonstationary models. For example, unit root tests focus mainly on the case of iid errors, and cointegration concentrates on vector autoregressions and integrated moving averages. However, the in-depth discussion of a narrowly focused class of models makes it easier to understand the fundamentals of these two topics. It also helps prepare readers for the study of a wider class of models, including those with dependent errors. If one wants a book with sound fundamentals and theoretical aspects of cointegration and unit root tests, this is that book.

Dhrymes begins with an introduction to time series, estimation, and prediction. These topics are preliminary to cointegration and unit root processes. Unit root processes and related asymptotic properties are then presented in a systematic manner in Chapter 3 by making a distinction between true and operational models, especially involving a constant term. Although the treatment is thorough for the case of iid errors, some discussion about autocorrelated errors would be desirable. Various aspects of cointegration are discussed in the next three chapters, which present rigorous characterization and implications of cointegration. Constrained estimation of the cointegrating vectors based on work of Ahn and Reinsel (1990) and Johansen (1988) is discussed, and a connection to canonical variables is made. A conformity test for cointegration based on an unconstrained estimator is discussed extensively. Probability topics such as Brownian motion, stochastic integration, and invariance principles are essential to understanding cointegration and unit root processes. The last three chapters provide a good overview of these topics and contain material pertinent to cointegration and unit root processes. These chapters come in handy reading Chapters 3–6.

It is worth comparing Dhrymes' book to the recent books by Hamilton (1994) and Reinsel (1997), which also cover cointegration extensively. Hamilton provides a "grocery store" of time series analysis, covering a vast range of topics with breadth, whereas Reinsel centers on analysis of multivariate time series. *Time Series, Unit Roots, and Cointegration* complements these two books, and vice versa. As noted in the Preface, this book can be used as a secondary textbook or a reference in an advanced graduate-level time series or econometrics course. It can also be used as a primary textbook in a course on unit roots and cointegration. This book should be included in a required reading list for those who study multivariate time series or econometrics.

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