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A COMPARATIVE STUDY OF INTRODUCTORY AND UNDERGRADUATE ECONOMETRIC TEXTBOOKS

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A Comparative Study of Introductory & Undergraduate Econometric Textbooks

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Abstract

There is at present a surfeit of introductory and undergraduate econometric text books. This can prove unfortunate for both the new student of econometrics wishing to purchase a textbook, and for course conveners whom have the responsibility of recommending a textbook. In a recent paper Granger (1994) reviewed graduate level textbooks, but there still remains a shortfall in the literature reviewing introductory/undergraduate texts. This paper is an attempt to fill this gap, by comprehensively reviewing what we consider to be the major mainstream introductory or undergraduate econometric textbooks. Our approach differs from Granger (1994) in that we do not attempt to give a formula for the "ideal" text, but simply evaluate what is currently available. Our research indicates that Maddala (1992) is the best introductory text, with Greene (1992) being more useful in later studies.

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1. Introduction.

There is at present a surfeit of introductory and undergraduate econometric text books. This is unfortunate for both the new student of econometrics wishing to purchase a textbook, and for course conveners invested with the responsibility of recommendation of such. The problem arises as a result of a shortfall in the literature reviewing such textbooks and thus providing assistance for the appropriate choice of textbook. This paper is an attempt to fill this gap, by comprehensively reviewing major mainstream undergraduate econometric textbooks.

Due to the multiplicity of texts available, our attention was restricted to those which specifically focus on econometric theory. Thus texts which are of a more applied nature (for example, Körösi *et al.* [1992] and Berndt [1991]) were not considered. Also, texts aimed at specific areas of econometrics were omitted (for example Harvey [1990] and Cuthbertson *et al.* [1992] on time-series) as were texts targeted at a graduate level (such as Davidson and MacKinnon [1993]). The texts considered are: Greene (1993); Griffiths, Hill, and Judge (1993); Johnston (1987); Judge, Hill, Griffiths, Lütkepohl and Lee (1988); Maddala (1992) and Stewart (1991). In his review of graduate texts for the American student, Granger (1994) includes both Greene and Griffiths *et al.*, but does state that Griffiths *et al.*

> "..*would be very appropriate for undergraduate courses in most universities in Europe, Asia, or Australia.*"[1]

Thus all of the books offer something for both the undergraduate student, and the graduate student embarking on their first econometrics course. Moreover, all of the texts have at some time been prescribed texts for undergraduate econometric courses at major universities worldwide.

In the selected six books, there are approximately 4,000 pages of text in total. This is too much for the researcher to read fully in detail. We attempt our review by listing the major areas of econometrics that should be covered in such a text, and then evaluate each of the texts' coverage of such (being highly dependent on chapter headings and indexes). In this approach we differ from Granger (1994) who attempts to give a formula for an ideal text, whereas we simply evaluate what is currently available.

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[1]*ibid.*, p. 116.

The plan of this paper is as follows. In the following section we discuss certain introductory elements to econometrics that are covered to varying extents in all of the above texts. Next, we consider the treatment of the classical linear regression model (CLRM), which typically forms the core of basic econometric courses. In Section 4 we consider treatment of the violations of the assumptions underlying the CLRM (heteroscedasticity, autocorrelation, and stochastic regressors). Data problems, such as multicollinearity are dealt with in Section 5. Section 6 considers the treatment of lagged models. Time-series modelling, unit roots and cointegration are dealt with in Section 7. Maximum likelihood estimation (MLE) and large sample theory, the use of dummy variables and, systems of equations are dealt with in Sections 8 to 10 respectively. Section 11 is concerned with certain additional topics not covered in the previous sections.

At the end of each section, we state the preferred choice for that particular topic. In Section 12 we draw some conclusions and make our final recommendations. This section also includes a ranking in Table 1, which lists the relative merits of the texts considered. In the Appendix, Tables 2 to 5 provide a summary of: additional topics (Table 2); estimators (Table 3); hypothesis tests and model selection criteria (Table 4) and; exercises, software and references (Table 5).

2. Statistical and Mathematical Background.

In order to be "self-contained", an econometrics textbook should contain certain basic mathematical techniques that are not specific to the field of econometrics. The surveyed books may be grouped into three broad categories. Firstly, Johnston and Stewart contain very little in terms of statistical/mathematical background, only offering a general introduction before the text proper begins. The only detailed coverage in both texts is of matrix algebra, with Johnston's coverage being marginally fuller. However, Johnston does also deal with such topics as differentiation (notations and conventions only), random variables and distributions, but the coverage is somewhat sparse and restricted to an appendix.

Griffiths *et al.* and Maddala fall into the second category of books. These cover the basics, but not to a level that might be useful at a higher level of study. Griffiths *et al.* provides a comprehensive review of the necessary introductory material, with the exception of matrix algebra (only focussing on those elements which deal directly with regression). The section includes useful and relevant exercises, introduces Monte

Carlo numerical methodology and also provides a succinct summary at the conclusion of the chapter(s). This section is equivalent to a general first-year undergraduate course in business statistics, and may negate the need for a separate first year textbook. On the other hand, Maddala, whilst covering the basics, assumes a certain amount of knowledge (equivalent to that taught in a first-year undergraduate course). Moreover, the section in Maddala does not cover additional topics covered in Griffiths *et al.* (such as elasticities and differentiation rules) and also contains no proofs.

The remaining texts assume a certain amount of prior knowledge, and expand concepts which may be utilised at higher levels of study/research. This creates a problem at a strictly introductory level, and students would need to look elsewhere to improve their basic calculus techniques, for example, before turning to Greene and Judge *et al.*. Both texts provide excellent refreshers for later year students, expressing the foundations of econometrics via comprehensive and lucid discussions. A distinguishing feature of Judge *et al.* is a section on Bayesian inference. Notwithstanding this, the overall coverage of Judge *et al.* is not as wide as in Greene.

Thus Griffiths *et al.* provides an excellent self-contained reference for all of the introductory material. If, however, study/research is likely to proceed on to a more technically advanced level, *and* if the reader has a sufficient knowledge of elementary statistics and calculus, then the appropriate choice is Greene.

3. The Classical Linear Regression Model (CLRM).[2]

The treatment of the CLRM is central to all of the texts, and an appropriate amount of time and space is devoted to this topic. Indeed, it is somewhat difficult to distinguish between the texts, as the material and extent of coverage is very similar, and of a high standard.

All of the texts cover basic regression techniques and standard extensions to this procedure. Thus such topics as: the derivations and properties of the (simple and multiple) Ordinary Least Squares (OLS) estimator; significance testing procedures; prediction, and so on, are included in all of the texts in some detail.

[2]For a summary of the relevant estimators and hypothesis tests (and model selection criteria), for this and subsequent sections, see Tables 3 and 4 in the Appendix.

The regression section of Maddala is easy to read and is expressed clearly. More difficult sections, such as MLE[3] and proofs, are contained in appendices, as are matrix derivations. This separation of proofs from basic principles, makes the text very easy to follow. Live data examples are given, to illustrate potential problems which may arise, and are discussed throughout the text.

Stewart is similar to Maddala, in that although the requisite areas of theory (with proofs and derivations) are given they are not imperative to a general understanding of the topic. In both texts the reader is guided through the pitfalls of empirical econometrics with live data and given a good idea as to how to proceed in empirical work. Finally, both texts give the impression that sub-sections are self-contained and that it is not necessary to have read preceding sections. However, for teaching purposes, a major drawback of Stewart is that it does not contain any exercises.[4]

Griffiths *et al.* also provides an excellent "hands-on" approach to basic regression theory, but is far more extensive. The reader is carefully guided through the same steps, accompanied with numerous simulated and live data examples. A distinguishing feature of the text is that critiques of methods are provided, as is a summary, in each chapter. The text provides an excellent grounding in both regression theory and practice.

Compared to Maddala and Stewart, Greene is less applied (although some live data examples are given). The text is primarily aimed at later year students, so the expositions may be a little difficult for novices to follow. In light of this, a full understanding requires preceding sections to have been read.

Although not as demanding as Greene, Judge *et al.* is similarly more theoretical in its exposition of regression techniques. Examples are provided, but the majority of the text deals with theoretical results and their proofs. The text quickly focuses on MLE, to the detriment of its treatment of OLS. Furthermore, Bayesian methods for regression are provided, taking the coverage somewhat outside the scope of this section. Finally, Johnston's coverage is similarly theoretical, but a lack of live data examples leaves the reader with limited practical awareness.

In the treatment of regression analysis, the overall standard is very high. For an easy to follow (and yet comprehensive) text which gives a feeling for empirical analysis,

[3]MLE is dealt with in Section 8 below.
[4]This is true for all sections in Stewart.

there is little to choose between Stewart and Maddala. For a predominantly theoretical text, there is little separating Johnston, Greene and Judge *et al.*. For a combination of both however, the most appropriate text is Griffiths *et al.*.

4. Violations of the Classical Assumptions.

We next consider the treatments when the classical assumptions underlying the CLRM are violated. A discussion of this topic necessarily involves a discussion of Generalised (and Feasible) Least Squares Estimation (GLS and FGLS). Some of the texts have a sole *Non-Spherical Disturbances* section (Johnston and Stewart); Maddala devotes whole chapters to heteroscedastic and autocorrelated disturbances and; the rest (Greene, Judge *et al.* and Griffiths *et al.*) have both introductory chapters to GLS estimation/non-spherical disturbances, and specific chapters on heteroscedastic and autocorrelated disturbances. For both teaching purposes and for a general exposition of the topic, those texts with self-contained chapters are more satisfactory.

4.1. Heteroscedastic Disturbance Terms.

Those texts which contain only one general section tend to be brief. For example, Johnston gives a formal treatment, and describes the mainstream tests (Breusch-Pagan, Goldfeld-Quandt and Glesjer) in detail, but gives no numerical worked examples. Stewart, on the other hand, treats the topic at a more applied level, providing worked examples on the tests considered.

The heteroscedasticity chapter in Maddala is concise and easy to follow. It contains descriptions of all the major tests, and includes numerical worked examples. The text takes an applied approach and consequently, more practical remedies are offered than any of the other texts. The text is, however, too brief.

The fact that the remaining texts have introductory chapters gives them an immediate advantage. Thus in Greene, Judge *et al.*, and Griffiths *et al.*, the reader is introduced to the topic of non-spherical disturbances and GLS estimation before proceeding on to specific areas, such as autocorrelation.

Of the three, Griffiths *et al.* probably has the briefest exposition of heteroscedasticity. Although concise, the text does cover the major tests with numerical worked examples, but only a heuristic justification of the tests is given. Both of the remaining texts (Judge *et al.* and Greene) are very comprehensive and extend coverage to a higher level (for example discussion of MLE). All tests, with derivations, are covered and both contain numerical worked examples, but Greene marginally surpasses Judge *et al.* in its exposition. Although the texts have less hand-holding than Maddala (for example) the sections are within the grasp of early year undergraduate students, and moreover supply additional material that would be appropriate for later year study.

In summary, for a concise, if somewhat elementary, text which has a strong practical component, Maddala is the appropriate choice. However, for a more advanced understanding, with less emphasis on applied work, Greene is our recommended text.

4.2. Autocorrelated Disturbance Terms.

As with heteroscedasticity, those texts (Johnston and Stewart) without a specific chapter dedicated to autocorrelated disturbances tend to be brief. Stewart provides a preliminary discussion, setting up a general framework to which remaining discussion is related back to. GLS estimation is covered, as are the Durbin-Watson (DW) test, the Cochrane-Orcutt method and MLE. Unfortunately explanations of concepts and practical problems are stated rather than derived. Johnston has a solid introductory section, deriving autocorrelation functions to be used in later discussions. The coverage is more theoretical than Stewart, concerned with discussing the consequences of autocorrelation on the OLS estimator. Estimation is covered in some detail, with an additional section on prediction. Overall, the section is rather theoretical and lacks examples.

Maddala devotes an entire chapter to autocorrelation, and as such covers the topic in more detail. The exposition begins (strangely) with the DW test. The test is not derived but is discussed well, in a practical manner with an illustrative example. The practicalities of estimation in levels and differencing are portrayed with simple examples. Spurious regression is also discussed as a potential problem for the applied worker. Testing for fourth-order autocorrelation is also covered. The essentials of estimation (GLS and FGLS) are discussed and matrix notation avoided. The chapter provides a sound explanation on the effects of AR(1) errors on OLS estimates, as well as discussing other tests for autocorrelation (including tests for higher order autocorrelation). Finally, a "remedy" section is presented, which guides students as to how to proceed when faced with autocorrelated errors. Explanations are clear and while the main points are discussed in simple terms, extended topics are also available (for example, on trends and random walks).

Griffiths *et al.* covers the topic in a similar vein to Maddala. The focus is on understanding and applying techniques, rather than being purely theoretical. The main points are covered in some length, with a solid discussion of the bounds test. Forecasting in the AR(1) model is covered well, with an appropriate example. At the end of the chapter there is also a useful summary of the results derived. While relevant material is covered adequately, the topic is not explained as well as in Maddala.

Judge *et al.* provides a very good theoretical exposition of the topic. Derivation of the generalised variance-covariance matrix is particularly well covered, accompanied with an excellent discussion of the DW test (and various other related tests). Practical problems are not considered, but the theoretical aspects are well set out and supported by numerous examples. Finally, Greene also follows a theoretical treatment of autocorrelation. The introduction to the topic explains autocorrelation clearly, aided by a diagrammatic example of an autocorrelated series. The basic concepts of estimation, testing, *etc.*, are adequately covered. The chapter is very detailed and includes an additional section on autoregressive conditional heteroscedasticity (ARCH) disturbances. The material is approximately equivalent to Judge *et al.*, but covers marginally more material, such as AR(2) and ARCH disturbances (although Judge *et al.*'s coverage of the DW test is superior).

From a practical viewpoint, Maddala is the best text. At a theoretical level, Greene and Judge *et al.*'s coverage is equivalent, being fuller than that of Johnston.

4.3. Stochastic Regressors and Lagged Dependent Variables.

Stochastic (or partially stochastic) regressors will in practice be: lagged dependent variables; explanatory variables which have measurement error; or proxy variables. The texts differ vastly as to which of these are covered and the extent of coverage.

Most of the texts (Maddala, Johnston, Griffiths *et al.* and Greene) contain a separate section on *data problems*, *errors in variables*, *etc.*, discussing lagged dependent variable (LDV) estimation in chapters on lag models. Judge *et al.*, provides a self-contained chapter on all stochastic regressors. Finally, Stewart addresses the estimation issues of a model containing a LDV (in a chapter on lag models), but neglects all other sources of stochastic regressors.

Maddala addresses estimation involving a LDV only in terms of models of expectations. The bias and consistency properties of the OLS estimators in this situation are not examined; inconsistency (when residuals are autocorrelated) is stated and the reader is simply pointed in the direction of instrumental variable (IV) estimation. Formal treatment of stochastic regressors is restricted to an appendix (to the chapter on simple regression) and within the chapter dealing with errors in variables. However, a more thorough coverage of other stochastic regressors is provided. The discussion includes proxy variables and other data problems, such as correlated errors and omitted variables.

A basic and fragmented treatment of LDV estimation is provided by Griffiths *et al.*. Properties of OLS estimators are derived, as are the associated IV estimators. However, there are few numerical examples and only a brief mention of alternative procedures (non-linear least squares [NLS]). The main problem with the coverage of this topic is that the material is difficult to find. Other stochastic regressors (or errors in variables) are dealt with in the large sample theory chapter. The main points of how measurement errors can arise, and the statistical consequences of them, are adequately covered. Points raised are ably supported by straightforward examples (especially on IV estimation and tests for correlation between the explanatory variables and the disturbance term). The topic is brief but well discussed, and the reader guided through the topic to a large extent.

Although Stewart does not specifically consider any source of stochastic regressors other than LDV's, this subject is competently tackled. In another chapter, there is a formal and general discussion of the properties of OLS estimators when there are stochastic regressors present. However, in the chapter on lagged models these are re-presented in the context of a LDV. Where there is residual correlation in addition to the LDV, IV estimators are offered as a first solution. The reader is then made aware however, that this still ignores the autocorrelation in the residuals. A re-parameterisation and NLS/ML techniques are then offered by Stewart. Finally, an empirical example is provided.

Greene gives a concise treatment of LDV estimation. Full proofs of OLS properties are given, and although NLS is not discussed, the problem of IV estimation with residual correlation is addressed in the context of a FGLS procedure. The treatment though, suffers from a lack of both hypothetical and real life data examples. However, a substantial amount of literature is included in the section on lag models (see Section 6 below) on various estimation techniques (ML and NLS, for example), which includes real life empirical examples. An entire chapter is devoted to *data problems* (half of which deals with multicollinearity). This section includes: measurement errors; proxy variables; IV estimation and; tests of measurement error, providing the reader with some advice on good econometric practice. Problems are discussed comprehensively, as are the means to overcome them.

The only criticism of Johnston's section on LDV's is that no numerical examples are given. Full proofs of the properties of OLS estimators are derived, as are the associated IV and ML estimators. As with Greene, the analysis is extended to cover estimation of a dynamic model with moving average disturbances. With regard to the errors in variables problem, Johnston is easily understood and covers the consequences of errors in variables and IV estimation well.

Overall though, Judge *et al.* provides the best coverage for stochastic regressors (including LDV's). All of the necessary proofs and estimation techniques are available in one convenient section, and plenty of numerical examples are provided.

5. Data Problems in the Classical Linear Regression Model (CLRM).

As with the previous sections, some of the texts have separate chapters on multicollinearity and other *data problems* (Maddala, Judge *et al.*, Griffiths *et al.*). In the remainder, these topics are nested within broader chapters. Again, the former texts facilitate an easier understanding of the issues. As most of the topics have been discussed in Section 4.3, we focus our discussion in this section on multicollinearity.[5]

5.1. Multicollinearity.

Multicollinearity could be considered as the "forgotten violation", and its treatment in some of the texts reflects this. For example, the treatment of this topic in Stewart is inadequate. The section is brief on the detection of multicollinearity (focussing on auxiliary regressions), few solutions and proofs are offered, and no data examples are

[5]It could be argued that errors in variables is also a data problem, but as with most of the texts, we discuss the topic concurrently with random regressors.

given (which is unfortunate since multicollinearity is strongly data related). The section does however, cover the basics of the effects of multicollinearity on OLS estimators and the obvious signs of its presence (as do all of the texts).

The coverage of this topic in Griffiths *et al.* is similarly meagre. The section is well written and easy to follow, but lacks substance. In the detection of multicollinearity, the text provides even less than Stewart (but the solutions offered are similar). Real life data examples are included, which is useful, but this could be expanded by the inclusion of artificial data to illustrate concepts. No proofs are provided, so the student must take statements on blind faith.

In terms of rankings, Greene and Johnston would rate higher than the above texts respectively. Detection methods are now expanded to include such techniques as the use of condition numbers and variance decomposition (although the latter is also touched upon in Stewart). Similarly, the treatment of remedies is expanded in both to include ridge and principal components regressions, for example. Greene and Johnston suffer from the exclusion of artificial and real life data examples, respectively.

For the preferred text for this topic there is little to choose between Maddala and Judge *et al.*. Detection of multicollinearity in both now includes: variance inflation factors; auxiliary regressions; principal components; Theil's method; sample correlations and; matrix decomposition. Slightly more solutions are offered in Maddala (specifically the use of prior information), which is consistent with the more applied approach of the book. The only drawbacks of these texts are that in Maddala the proofs are relegated to an appendix, and that Judge *et al.* suffers from a lack of artificial data examples.

5.2. Other Data Problems.

The discussion of errors in variables and proxy variables has been covered in Section 4.3, and as such are not included as a data problem *per se*. Only Greene discusses other data problems separately, which include missing observations and self-selectivity. These topics are explained well, as are the means to overcome them. Problems arising from grouped data are also covered, accompanied by derivations of the mean and variance with grouped data.

6. Lag Models.

Since the seminal paper of Engle and Granger (1987), there has been an explosion in the field of the cointegration and vector autoregressions (VAR). Apparently this has been at the expense of "traditional" distributed lag models. However, students should still be aware of the traditional techniques for estimating lagged models as these still feature in many undergraduate courses.

Griffiths *et al.*, appears to suffer most from the above criticism. A student using this text in an attempt to estimate a distributed lag model via the Almon procedure, would find themselves: unable to readily construct the required exogenous ("*Z*") variables and recover the original parameters; unable to recover the standard errors of the original parameters; uncertain about determining the degree of the approximating polynomial and lag length and; ignorant of the problems associated with this procedure. The text attempts to provide an economic motivation for distributed lag models. However, only the adaptive expectations hypothesis (AEH) is considered and the partial adjustment model (PAM) is ignored. Also, in this section, rational expectations are omitted.

Testing for the "correct" lag length is important in lag models. This procedure will invariably involve *sequences* of tests. However, in Griffiths *et al.* the issue of pre-test bias is not addressed, and there is very little coverage of the whole issue of testing. Other notable exclusions from Griffiths *et al.* are: short- and long-run multipliers; mean/median lags; stability conditions and; rational distributed lags.

Judge *et al.* is also weak in its treatment of lagged models. Much time is spent on determining the lag length (including the use of information criteria and sequential testing) which is useful for the applied researcher. However, the depth of this (introductory) section adversely affects that of the remainder of the section. There is no mention of: mean/median lags; short/long-run multipliers; stability conditions; rational expectations; the combination of the AEH and PAM; transformation of the AEH model into an estimable form and finally; the Almon procedure is not fully spelt out. The text does however, provide a useful table of the results of a Monte Carlo experiment comparing OLS, IV and ML estimators. Finally, the pertinent point is made that all of the testing procedures are based upon "well-behaved" disturbances, an assumption not valid in most lagged models. However, armed with this knowledge, the student is not told how to proceed![6]

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[6]At least the point is made however, unlike the other texts.

The exposition of lagged models in Maddala is restricted to the chapter on *Expectations*. Although the text is very comprehensive in terms of expectations (being the only text that explicitly deals with rational expectations), the treatment raises several issues. Firstly, there is no discussion of the Almon procedure. Secondly, to be somewhat pedantic, the PAM is not an expectations model and therefore should not be in this section. Finally, and most importantly, the student may be left believing that lagged models only arise from models of expectations.

Stewart's section on lagged models is adequate, but neglects both the combination of the AEH and PA models and rational expectations. Stewart is scant on the Almon procedure, not showing how one might determine either the degree of polynomial or the lag length, or indeed any problems associated with the technique. Johnston, on the other hand, provides a fuller exposition, although it does have drawbacks. No numerical examples are given, and both pre-testing and determining the "correct" lag length are ignored. A salient feature of Johnston is a convenient table which lists the appropriate estimation technique(s) for all of the various models.

Finally, Greene provides the most comprehensive coverage of this topic, with the only exclusions being those of rational expectations and the combination of AEH and PA models.

7. Time-Series, Unit Roots and Cointegration.

The topics of time-series, unit roots and cointegration are inter-linked in most of the texts. Generally, the concepts of stationarity and integration are introduced via autoregressive integrated moving average (ARIMA) models. The topics of unit roots and cointegration naturally follow. Being a relatively new area of study, some of the older texts (Judge *et al.* and Johnston) do not cover cointegration at all. However, given the importance of the topic, an introduction, at the very least, is imperative.

7.1. Time-Series Modelling.

Most of the texts discuss some of the preliminary aspects of time-series modelling (such as autocorrelation functions [ACF]) in their exposition of autocorrelated disturbances. Consequently, some of these preliminaries are only briefly discussed in time-series sections, and the reader is referred back to the autocorrelation section. The time-series topic is different from the classical approach to econometrics. As such, students may have some initial difficulty in coming to grips with the basic concepts underlying this "new" modelling approach. Consequently, those texts that use explanatory diagrams tend to illustrate the topic more clearly.

All texts introduce the reader to the fundamentals of time-series analysis, such as the ACF, stationarity, ARIMA models, forecasting and the Box-Jenkins methodology. A notable exception is Johnston. The topic is included in the LDV section and the discussion is tied to distributed lag models. Only the very basic concepts are covered (*i.e.* ACF's and ARIMA type models), and the Box-Jenkins procedure is disregarded.

The remaining texts are similar in their coverage. Stewart discusses the main issues of time-series modelling and the Box-Jenkins methodology. Results are invariably presented and proofs are referred to earlier coverage of autocorrelated disturbances. A reasonable overview of diagnostic checks is provided, but there is a disappointing lack of discussion on how to employ them and their inherent problems (this is also true of most of the texts).

Judge *et al.* deals with the topic in some depth, especially in the derivations of ACF's and estimation (particularly of a moving average process). The major drawback is that there is no discussion on seasonality, which is an important issue in time-series modelling.[7] Despite this however, the topic is generally well covered, especially with regard to both point and interval forecasting.

Maddala avoids complicated technical detail. Discussion is kept simple and is easily understood. Diagrams are used extensively, especially in the identification of ARMA models. ACF's *etc.* are derived, with a brief discussion on the problems of some of the diagnostic tests. A useful assessment of the Box-Jenkins methodology is provided, highlighting some of the more practical issues of time-series modelling.

Griffiths *et al.*, also tackles the topic from a more practical viewpoint. A noticeable feature is that diagrams are extensively used, providing a comprehensible discussion. An entire chapter is devoted to the topic, allowing issues to be discussed in some depth. However, a significant drawback is a lack of discussion on some of the problems associated with time-series modelling, in particular, seasonality (although a summary of issues not discussed in the chapter is provided).

[7]The authors do, however, provide a summary of the issues they have omitted toward the end of the chapter, and also provide a suitable reading guide.

Greene's coverage of the topic does not flow well. A very brief introduction to the basic concepts of univariate time-series modelling is followed by consideration of multivariate time-series models. The discussion then returns to the univariate case, with results stated rather than being derived. While a good discussion of stationarity is provided, the topic is not covered extensively.

No text stands out in this topic. All texts (except Johnston) cover the same material in a similar manner. The most disappointing aspect is that there is a severe lack of discussion on the use of time-series methods in practice. Indeed, it is this practical issue that causes students most problems in this area. For example, the texts do not deal well with the identification problems of mixed ARIMA models. Maddala and Griffiths *et al.* are more practical than the others, although Judge *et al.*'s coverage of forecasting and its overall handling of the topic are very favourable traits for this text.

7.2. Unit Roots and Cointegration.

The topic of unit roots and cointegration quickly becomes very theoretical, so it is difficult to keep all of the discussion at an introductory level. Consequently the texts seem to discuss the underlying concepts of the topic and state results rather than deriving them. In discussing cointegration, many of the texts include some coverage of VAR's. Judge *et al.* also provides a good coverage of VAR models which may be used as an introduction to this topic.

Maddala, being a recent text, covers the topic well. VAR's are discussed initially, followed by a sound discussion on unit roots (including testing). Methods are given and discussed in some detail, making this potentially confusing topic accessible to the student. The topic of cointegration naturally follows, with the discussion being brief and basic, yet clear. Structural change, cointegration and cointegrating regressions are discussed and illustrated with examples. Vectors of cointegrating relationships are also considered along with some practical tests of economic theory for which these models may be utilised. Overall the discussion is very clear and understandable, covering all of the basics a student needs to gain a sound introduction to a potentially difficult topic.

Stewart similarly provides a sound introduction to cointegration. Unit root tests are discussed, as are cointegrating regressions and error correction models. A succinct coverage of the topic is given, only providing an overview of the issues. In a similar vein, Griffiths *et al.* provides a solid discussion on the techniques used in this area without going into too much depth. Greene also provides a brief introduction to the area. Its coverage of unit roots and their associated tests is superior to both Griffiths *et al.* and Stewart, with the discussion on cointegration and error correction being helpful, but unfortunately brief. All texts leave the reader with an intuitive feel for the topic, rather than a grasp of it.

It is obvious from the above discussion which text is superior in this area. Maddala puts the student in a position from which they can feel confident about the basics of the topic. Furthermore, they are exposed to cointegrating systems which puts them in a position where they have a basic grasp for this part of the cointegration topic. The remaining texts are very introductory, and whilst sound in their approach, do not offer as much benefit to the interested student.

8. Large Sample Theory and Maximum Likelihood Estimation.

Large sample theory is arguably one of the harder topics that a new student to the field will encounter. Thus, at an introductory and undergraduate level, only the basics of large sample theory are necessary. As MLE is generally used when OLS is not appropriate, then it would appear in its own right as an estimation technique in a limited dependent variable section, for example. However, ideally one would expect some introductory concepts and examples to be included in (or following) the large sample theory section.

All of the texts provide an adequate coverage of large sample theory. In Judge *et al.* and Maddala, this is nested within a section dealing with *properties of estimators*, and therefore is more difficult to find. The remaining texts have separate sections on large sample theory. The most thorough coverage of this topic is given by Greene. However, any text would suffice, as coverage to a level provided by Greene, is only required by the most ambitious undergraduate student.

Only Griffiths *et al.* fails to give an adequate introduction to MLE following the (required) large sample theory. This text's treatment of the ML principal is brief and difficult to find. A good coverage of this topic cannot be restricted to (or even introduced solely by) the usual regression model obeying Gaussian assumptions. A few simple examples of the ML technique is highly desirable, which is what sets Greene and Judge *et al.* apart from the others. In light of Greene's superior format and treatment of large sample theory, this is our recommended text for this topic.

9. The Use of Dummy Variables.

Under this heading we would expect the texts to cover a discussion of the use of dummy variables in the context of: varying intercept and response parameters; qualitative and indicator explanatory variables and; seasonality. From an applied perspective, the treatment of seasonality should include a discussion of the relative merits of using dummy variables and seasonally adjusted data. However, only Johnston covers all of these points, and moreover, illustrates them well with numerical examples. Of the other texts, a similar level of coverage is provided by Maddala and Greene, whose discussions do involve the use of dummy variables in the context of seasonality, but do not discuss seasonally adjusted data.

Both Griffiths *et al.* and Judge *et al.* provide a full coverage (the latter more so) on the use of dummy variables excluding seasonality. At the other end of the spectrum, Stewart provides a very good summary of the use of dummy variables in the treatment of seasonality to the neglect of all other uses. Therefore, as it contains the most thorough coverage and a discussion between the use of dummy variables and seasonally adjusted data, Johnston is our recommended text for this topic.

10. Systems of Equations.

Under this topic we include both simultaneous equation models and the seemingly unrelated regressions model (SURM). Only Maddala does not consider the SURM. This is unfortunate as it can be used as a springboard into pooled data topics such as panel models, which are becoming more prominent in the literature.

After motivating the topic with a strong introduction, Greene then provides a predominantly theoretical coverage of simultaneous equations. Identification and estimation issues are discussed clearly, supported by both empirical and diagrammatic examples. The distinguishing feature is the depth of coverage of estimation issues. The various estimators (and their relative merits) are discussed thoroughly and clearly. A similarly sound and lucid discussion on the SURM is provided (including the derivation of the FGLS estimator and an extensive exposition of MLE), with concepts supported by useful examples.

Judge *et al.* also provides a sound introduction to the topic, especially to simultaneity. The discussion is clear and concepts are introduced gradually, as with Greene. The coverage is split into two chapters, the latter dealing with estimation. This chapter is extensive and lucid. Estimation procedures and properties of estimators are covered in some depth. The SURM is used to motivate panel data models and, consequently, provides an easily understood introduction. The main aspects are considered and are supported well with good examples.

Johnston provides a sound coverage of simultaneous equation models, but lacks depth. All relevant concepts are covered, but the discussion is not as extensive as in either Greene or Judge *et al.*. Johnston's coverage of the SURM is comparatively brief, being considered only within the context of GLS. The discussion is particularly theoretical and lacks useful examples. Stewart also provides little motivation to the topic. The SURM and simultaneous equation models are covered, but with little detail. Simple examples are given, providing the reader with an intuitive feel for the issues involved in the area and giving only a basic coverage of the topic.

A good introduction to simultaneous relationships is provided by Griffiths *et al.*. Technical detail is left to an appendix and identification, in particular, is covered well. As with Judge *et al.*, the topic is split into two chapters. The first chapter provides a solid discussion, introducing the theory and models. The estimation chapter gives a clear and extensive coverage of two- and three-stage least squares estimation (the latter in an appendix). Concepts are discussed in detail and clearly, with a drawback being the lack of discussion of MLE. A similar coverage to Judge *et al.* of the SURM is provided. The introduction and motivation to the topic is excellent, with technical details in an appendix, enabling the discussion to remain clear to the reader.

Maddala also provides a more practical coverage and avoids becoming technical. A strong motivation for the topic is given, discussing identification issues very well, but, full information estimators and the SURM are omitted. The discussion of limited information maximum likelihood estimation is very good, especially on its problems and on the concepts of exogeneity and causality. Overall the discussion is sound, being basic yet explanatory. A main attraction to the student is that the topic is covered at a basic level, but some technical detail is provided in an appendix if it is required.

Overall the texts cover the area thoroughly. For a theoretical coverage of the topic, there is little to choose between Judge *et al.* and Greene. For a more basic and applied introduction, Griffiths *et al.* and Maddala are difficult to separate, but the fact that Maddala omits the SURM is a disadvantage.

11. Additional Topics.

The preceding sections contain what we consider to be the core topics of an introductory/undergraduate textbook. However, all of the texts have additional topics which are covered to varying degrees, which may have not been fully considered above. We do not consider these in detail, but list them (in no particular order) with an approximate page count, in the Appendix, Table 2. Supplementary information on exercises, software support and references is also provided in Table 5.

12. Conclusions and Recommendations.

To aid the drawing of conclusions, we present rankings of the texts in the areas considered in Sections 2 to 10 above. Texts are given a value of between 1 and 6 for each topic, with 6 ranking the highest and indicating that the text is the best of the texts considered, and not that the treatment is necessarily "ideal". Where not all texts addressed a topic, rankings were scaled down accordingly. These rankings are presented in Table 1 below.

Table 1 illustrates that there is very little between Maddala and Greene. From a purely introductory perspective, Maddala is our recommended text. The separation of basic concepts from proofs and technical details (in appendices) allows the fundamentals of econometrics to be easily understood by the novice. This is highlighted by the use of matrix algebra being kept to a minimum (see Table 3 in the Appendix). Nevertheless, the range of topics covered by Maddala is wide (Tables 3 and 4). Finally, for teaching purposes, data is provided, as are solutions to the numerous exercises, and the references provide a useful guide to further reading (Table 5). This text is ideally suited to a practical econometrics course for the non-specialist student.

On the other hand, if the student requires an all encompassing text for use in both later studies and the workplace, the depth of Maddala would be insufficient and Greene would be appropriate. The range of topics covered in Greene is wider than that of Maddala (Tables 1 to 4 in the Appendix) and a greater level of software support is potentially available (Table 5). This text is ideally suited to a technical econometrics course for the specialist student, who is likely to take the subject to a higher level.

Table 1

Summary Information on the Texts Surveyed.

	Griffiths *et al.*	Greene	Johnston	Judge *et al.*	Maddala	Stewart
Introductory Statistics	6.0	5.0	2.0	4.0	3.0	1.0
CLRM	6.0	2.0	2.0	2.0	4.5	4.5
Heteroscedasticity	3.0	5.5	1.5	4.0	5.5	1.5
Autocorrelation	3.0	4.5	1.0	4.5	6.0	2.0
Stochastic Regressors	3.0	3.0	3.0	6.0	3.0	3.0
Multicollinearity	1.0	4.0	3.0	5.0	6.0	2.0
Other Data Problems	-	1.0	-	-	-	-
Lagged Models	1.0	6.0	5.0	3.0	3.0	3.0
Time-Series	5.0	3.0	1.0	5.0	5.0	2.0
Cointegration & Unit Roots	3.0	3.0	-	1.0	5.0	3.0
Large Sample Theory & MLE	1.0	6.0	3.0	5.0	3.0	3.0
Dummy Variables	2.0	4.5	6.0	3.0	4.5	1.0
Systems of Equations	5.0	5.0	2.0	5.0	3.0	1.0
Average	3.0	4.0	2.3	3.7	4.0	2.1

Of the other texts, Stewart ranks poorly but is still a convenient and easy to read introductory text. Johnston fares poorly on both time-series and cointegration and is probably in need of a new edition. Judge *et al.* is comparable to Greene, being more appropriate for later year students, but again is due for a new edition. This new edition could be considered to be Griffiths *et al.* (the texts share three common authors). This text bridges the gap between a specifically introductory text, and one that can be used at higher levels. The references are particularly useful, providing a convenient summary for further reading (Table 5). Many additional topics are provided (Tables 2 to 4), several of which an applied economist might find useful in the workplace. This text is well suited to many introductory courses for both the specialist and non-specialist student.

Hopefully we have provided some assistance to both lecturers and students alike in their choice of text(s), although the ultimate decision is of course a personal one.

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Körösi, G., Mátyás, L. and Székely, I.P. (1992), *Practical Econometrics*, Avebury Publishing, Aldershot.

Maddala, G.S. (1992), *Introduction to Econometrics*, 2nd Edition, Macmillan Publishing Company, New York.

Stewart, J. (1991), *Econometrics*, Philip Allen, New York.

APPENDIX

Table 2

*Chapter/Section Headings of Additional Topics Covered with Approximate Page Count.**

Griffiths et al.

- The Simple Linear Statistical Model: Choosing the Functional Form, Reporting Results, and Carrying Through an Econometric Analysis - 34.*
- Combining Sample and Nonsample Information and Further Applications of the General Linear Statistical Model - 33.*
- Varying Coefficient Models - 4.
- Combining Cross-Sectional and Time-Series Data - 9.
- Nonlinear Least Squares - 23.*
- Models with Discrete Dependent Variables - 25.*
- Bayesian Estimation and Inference - 66.**
- Economic Data Sources, Guidelines for Choosing a Research Project, and the Writing of a Research Report - 16.*

Greene

- Functional Form, Nonlinearity, and Specification - 37.*†
- Nonlinear Regression Models and An Introduction to Nonlinear Optimisation - 44.**
- Models That Use Both Cross-Section and Time-Series Data - 42.*
- Models With Discrete Dependent Variables - 47.*
- Limited Dependent Variable and Duration Models - 46.**

Johnston

- Pooling of Time-Series and Cross-Section Data - 11.
- Variable Parameter Models - 12.
- Qualitative Dependent Variables - 9.
- Econometrics in Practice: Problems and Perspectives - 19.*

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† Contains approximately 9 pages on dummy variables, considered in Section 9.

Table 2 (cont.)

*Chapter/Section Headings of Additional Topics Covered with Approximate Page Count.**

Judge et al.

- Bayesian Inference and Bayesian Analysis of the Normal Linear Statistical Model - 90.**
- Varying Parameter Models - 5.
- Pooling Time-Series and Cross-Section Data - 25.
- Nonlinear Least Squares and Nonlinear Maximum Likelihood Estimation - 74.*
- Qualitative and Limited Dependent Variable Models - 23.*
- Prior Information, Biased Estimation, and Statistical Model Selection - 53.*
- Robust Estimation - 30.*

Maddala

- Truncated Variables - 23.
- Diagnostic Checking, Model Selection, and Specification Testing - 30.*

Stewart

Limited Dependent Variable Models - 10.
Some Questions of Methodology - 6.

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* Denotes a full chapter.

** Denotes more than one chapter.

Table 3

*Estimators and Model Selection**

	Griffiths *et al.*	Greene	Johnston	Judge *et al.*	Maddala	Stewart
OLS	A†	A†	A†	A†	A†	A†
Rest. LS	D†	C†	C	C	-	C†
GLS	B†	C†	B†	C†	B†	C
FGLS	B†	C†	B†	C†	B†	C
NLS	D†	D†	-	A†	-	D†
2SLS	C†	C	A	C	D†	C†
IV	A†	C†	A†	C†	A†	C†
3SLS	C†	C	C†	C†	-	C†
MLE	A†	B†	C	B†	D	C
LIML	-	C†	C	C	D†	C
FIML	-	C†	C†	C	-	C
Cochrane-Orcutt	D†	A†	D	D	D†	D
Method of Moments	D	D†	-	D	D†	-
GMM	-	A†	-	-	-	-
Johansen	-	-	-	-	E	-
Engle-Granger 2-Step	D	D†	-	-	D	D†

* By reference to indexes.
- Not covered.

Key

A - Matrix and scalar derivations.

B - Predominantly matrix derivations with significant scalar contribution

C - Predominantly matrix derivations.

D - Predominantly scalar derivations.

E - Discussion only, no formulae.

† - Numerical examples given.

Table 4

*Hypothesis Tests and Model Selection Criteria**

	Griffiths *et al.*	Greene	Johnston	Judge *et al.*	Maddala	Stewart
t-test	A	A	A	B	A	A
F-test	A	A	A	B	A	A
R^2	A	A	A	A	A	A
$\overline{R}^2$	A	A	A	A	A	A
DW	A	A	A	A	A	A
Durbin's-*h*	-	A	A	A	A	B
Chow	-	A	A	-	A	A
LM	B	A	-	A	B	B
Wald	B	A	-	A	B	B
LR	B	A	-	A	B	B
Goldfeld-Quandt	A	A	A	A	A	A
Glesjer	-	A	A	-	A	-
Breusch-Pagan	A	A	A	A	A	A
AIC	B	A	-	A	A	A
BIC (Schwarz)	-	-	-	A	-	-
Dickey-Fuller	A	A	-	-	A	A
Phillips-Perron	-	-	-	-	A	-

* Based primarily on reference to indexes.

- Not covered.

Key

A - Substantial coverage.

B - Brief coverage.

Table 5

Exercises, Software Support and References

	Griffiths *et al.*	Greene	Johnston	Judge *et al.*	Maddala	Stewart
Exercises*	A,M	A,M	B	A,M	A,M	C
Software Support†	D,E	D♠	D	D,E	D	D
References‡	F,G	G	G	F,G	G	H

♠ Computer code and data supplied with purchase of computer package, LIMDEP©.

Key

* A - relevant and sufficient; B - relevant but insufficient; C - irrelevant or not included; M - instructor's manual available.

† D - data available, E - computer code available.

‡ F - useful summary given at end of section; G - appropriate for further reading; H - bibliographical references only.