AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

CANTER

9006

Department of Economics
UNIVERSITY OF CANTERBURY
CHRISTCHURCH, NEW ZEALAND

GIANNINI FOUNDATION OF
AGRICULTURAL ECONOMICS
LIBRARY

OCT 04 1990

THE OPTIMAL SIZE OF A PRELIMINARY TEST OF LINEAR RESTRICTIONS IN A MIS-SPECIFIED REGRESSION MODEL

David A. E. Giles, Offer Lieberman & Judith A. Giles

Discussion Paper

No. 9006

This paper is circulated for discussion and comments. It should not be quoted without the prior approval of the author. It reflects the views of the author who is responsible for the facts and accuracy of the data presented. Responsibility for the application of material to specific cases, however, lies with any user of the paper and no responsibility in such cases will be attributed to the author or to the University of Canterbury.

Department of Economics, University of Canterbury
Christchurch, New Zealand

Discussion Paper No. 9006

August 1990

THE OPTIMAL SIZE OF A PRELIMINARY TEST OF LINEAR RESTRICTIONS IN A MIS-SPECIFIED REGRESSION MODEL

David E. A. Giles, Offer Lieberman & Judith A. Giles

**Department of Economics
University of Canterbury
Christchurch, New Zealand**

THE OPTIMAL SIZE OF A PRELIMINARY TEST OF LINEAR RESTRICTIONS IN A MIS-SPECIFIED REGRESSION MODEL

David E.A. Giles

Offer Lieberman

&

Judith A. Giles*

August, 1990

Abstract

When the choice of estimator for the coefficients in a linear regression model is determined by the outcome of a prior test of the validity of restrictions on the model, Brook (1976) has shown that a mini-max (risk) regret criterion leads to the simple rule that the optimal critical value for the preliminary test is approximately two in value, regardless of the degrees of freedom. We show that this result no longer holds in the (likely) event that relevant regressors are excluded from the model at the outset.

Key Words : Preliminary Test; Conditional Inference; F-Test; Optimal Size.

* David Giles is Professor, Offer Lieberman is a graduate student, and Judith Giles is Lecturer, Department of Economics, University of Canterbury, Christchurch, 8001, NEW ZEALAND.

1. INTRODUCTION

Applied statisticians and econometricians routinely adopt a "preliminary - test" estimator (PTE) when using the linear multiple regression model. That is, they search for the preferred specification of the model by testing exact (and often "zero") linear restrictions on the coefficients, and then apply Ordinary Least Squares (OLS) or Restricted Least Squares (RLS) estimation according to the outcome of the test. (For example, see Bancroft (1944), Brook (1976), Judge & Bock (1978)). Of course, other pre-test regression strategies are also common, such as those associated with testing for homogeneity of the error variance (e.g. Toyoda and Wallace (1975), Bancroft and Han (1983)) and testing for serial independence of the errors (e.g., King and Giles (1984)).

The finite sample risks (say, under quadratic loss) of PTEs are complicated functions of all aspects of the problem, including the chosen size (and hence critical value(s)) for the two "component" estimators, and are discontinuous functions of the sample data. Accordingly, they are generally inadmissible (e.g., Cohen (1965)). However, PTEs are routinely used, often without an appreciation that their sampling properties differ crucially from those of the component estimators, and so they warrant close scrutiny.

Given that the risk of a PTE depends, in part, on the pre-test size, various criteria have been suggested for choosing the "optimal" size. In the case of the PTE arising from the testing of exact linear restrictions on the coefficients of the linear model, two such optimality criteria are those suggested by Brook (1976) and Toyoda and Wallace (1976).

A recent development in the literature on regression PTEs has been an investigation of the extent to which their properties are affected if the model is mis-specified in various ways (e.g., Ohtani (1983), Mittelhammer (1984), Giles (1986), Giles and Clarke (1989), Giles (1990)). To date, there has been no discussion of the effects that model mis-specification may have on

the "optimal" choice of pre-test size. This paper addresses this question by extending Brook's analysis to the important case where relevant regressors are omitted from the model.

2. THE MODEL AND DEFINITIONS

Suppose that the data-generating process is

$$y = X\beta + Z\gamma + u; \qquad u \sim N(0,\sigma^2 I) \tag{2.1}$$

where X and Z are (n×k) and (n×g) respectively, each of full rank and non-stochastic. However, the model fitted to the data is

$$y = X\beta + \varepsilon , \tag{2.2}$$

where $\varepsilon = Z\gamma + u = \xi + u$, say. Within the framework of the (mis-specified) model (2.2), we test m independent linear restrictions:

$$H_0 : R\beta = r \quad \underline{\text{vs}} \quad H_A : R\beta \neq r,$$

where R is (m×k), of rank m; r is (m×1); and both are non-stochastic. Being unaware that the model is mis-specified, we use the usual "F-statistic",

$$f = (r-R\tilde{\beta})'(RS^{-1}R')^{-1}(r-R\tilde{\beta})/ms^2,$$

where $S = X'X$; $\tilde{\beta} = S^{-1}X'y$ is the OLS estimator of β; $s^2 = y'(I-XS^{-1}X')y/\nu$; and $\nu = (n-k)$.

It is readily shown (e.g. Mittelhammer (1984)) that f is $F''_{(m,\nu;\lambda_n,\lambda_d)}$: that is, doubly non-central F with m and ν degrees of freedom, and non-centrality parameters

$$\lambda_n = (RS^{-1}X'\xi-\delta)'(RS^{-1}R')^{-1}(RS^{-1}X'\xi-\delta)/2\sigma^2$$

$$\lambda_d = \xi'(I-XS^{-1}X')\xi/2\sigma^2 ,$$

where $\delta = R\beta-r$.

The PTE of β is based on $\tilde{\beta}$; the RLS estimator of β, $\beta^* = \tilde{\beta} - S^{-1}R'(RS^{-1}R')^{-1}(R\tilde{\beta}-r)$; and the use of f to test H_0:

$$\hat{\beta} = \begin{cases} \tilde{\beta} & \text{if } f > c(\alpha) \\ \beta^* & \text{if } f \le c(\alpha) \end{cases}$$

where $c(\alpha)$ is the size-α critical value for the central F statistic with m and ν degrees of freedom.

The sampling properties of $\tilde{\beta}$, β^* and $\hat{\beta}$ will be compared on the basis of (relative) predictive risk under quadratic loss. For any estimator, b, of β, this is defined as $\rho\left(Xb,E(y)\right) = E\left[\left(Xb-E(y)\right)'\left(Xb-E(y)\right)\right]/\sigma^2$, which is equivalent to the risk of b itself with orthornormal regressors. So,

$$\rho\left(X\tilde{\beta},E(y)\right) = \left(k+2\lambda_d\right) \tag{2.3}$$

$$\rho\left(X\beta^*,E(y)\right) = \left(k+2\lambda_d+2\lambda_n-m\right) \tag{2.4}$$

$$\rho\left(X\hat{\beta},E(y)\right) = \left(k+2\lambda_d+(4\lambda_n-m)P_2-2\lambda_n P_4\right) \tag{2.5}$$

where $P_i = \Pr.\left[F''_{(m+i,\nu;\lambda_n,\lambda_d)} \le \frac{cm}{m+i}\right]$. See Mittelhammer (1984) and Giles (1990).

If $\xi = 0$, then $\lambda_d = 0$, the fitted model is correctly specified, and (2.3) - (2.5) collapse to the corresponding expressions given by Brook (1976). Note that $\rho\left(X\tilde{\beta},E(y)\right) = \rho\left(X\beta^*,E(y)\right)$ when $\lambda_n = m/2$, *regardless of the value of* λ_d. Also, from (2.3)-(2.5), it is readily shown for any λ_d (i.e. degree of model mis-specification), that $\rho\left(X\hat{\beta},E(y)\right) = \rho\left(X\tilde{\beta},E(y)\right)$ for some $\lambda_n \in (m/4,m/2)$; and

that $\rho\left(X\hat{\beta},E(y)\right)$ has a unique mode at a value of λ_n greater than that for which $\rho\left(X\hat{\beta},E(y)\right) = \rho\left(X\beta^*,E(y)\right)$. This is illustrated in Figure 1 for a specific degree of mis-specification. As Mittelhammer (1984) notes, the OLS, RLS and PTE risks are unbounded as $\lambda_d \to \infty$ (for a given λ_n). Further, for fixed c and λ_n, $\rho\left(X\hat{\beta},E(y)\right) \to \rho\left(X\beta^*,E(y)\right)$ as $\lambda_d \to \infty$.

3. OPTIMAL SIZE OF THE TEST

Clearly, from (2.5), the predictive pre-test risk depends on $c = c(\alpha)$. For any particular value of λ_d the predictive risks, as functions of λ_n, have the same essential characteristics as when $\lambda_d = 0$. In particular, of the three estimators considered, RLS is preferred if $\lambda_n < m/2$, and OLS is preferred if $\lambda_n > m/2$. We can define the "regret" associated with using the PTE as

$$R(X\hat{\beta}) = \begin{cases} \rho(X\hat{\beta}) - \rho(X\beta^*) \ ; & \lambda_n < m/2 \\ \rho(X\hat{\beta}) - \rho(X\tilde{\beta}) \ ; & \lambda_n \geq m/2. \end{cases}$$

As is well known, if $\lambda_d = 0$, then for any c there is a unique $R^L = \sup_{\lambda_n < m/2} R(X\hat{\beta})$ and a unique $R^U = \sup_{\lambda_n \geq m/2} R(X\hat{\beta})$. Further, an increase in c leads to a decrease in R^L and an increase in R^U. The same result applies for any fixed $\lambda_d > 0$. So for a given λ_d, an optimal choice of c may be defined as $c = c^*$ such that $R^L = R^U$, and both regrets are simultaneously minimized. This is the "mini-max - regret" rule adopted by Brook (1976) (and similar to that of Sawa and Hiromatsu (1973)) for the properly specified model (λ_d=0). The computations needed to obtain c^*, for any λ_d, are equivalent to those needed in Brook's case, but with doubly non-central F probabilities replacing his non-central F probabilities.

4. RESULTS

Optimal critical values, c^*, are reported in Table 1 for several values of λ_d. These were calculated using a FORTRAN program written by the authors and executed on a VAX8350. The program incorporates Davies' (1980) algorithm to evaluate the doubly non-central F probablities. The chosen degrees of freedom match those considered by Brook, and his results correspond to $\lambda_d = 0$. (There are some minor differences between our results and his for small and large degrees of freedom. These can be accounted for if one adopts less stringent convergence tolerences then we have used in our program.) The optimal significance levels (α^*) corresponding to c^*, and based on the central $F_{m,\nu}$ distribution, are reported in Table 1. These are also computed using Davies' algorithm.

The strongest feature of Brook's results for the properly specified model is that c^* is always close to two in value, regardless of the degrees of freedom. (Using a different criterion, Toyoda and Wallace (1976) concur with this result for $m \geq 5$.) As Figure 1 and Table 1 show, this result is undermined if the model is mis-specified through the omission of regressors. In this case c^* is sensitive to the degrees of freedom and can differ substantially from the values suggested by Brook. In addition, for any m and ν, c^* declines monotonically as the degree of model mis-specification increases. Accordingly, the optimal pre-test size (α^*) increases monotonically with λ_d, for fixed degrees of freedom. This accentuates the other strong feature of the results obtained by Brook (and Toyoda and Wallace (1976)) - the optimal pre-test size is frequently much greater than the commonly assigned sizes of 1% or 5%.

5. CONCLUDING DISCUSSION

We have focussed attention on pre-testing in the context of a model which is under-specified. The case where extraneous regressors are included in the model does not require separate consideration. Giles (1986) shows that all of the usual risk results hold (as in Figure 1, with $\lambda_d = 0$) in this case with a simple re-definition of λ_n. It follows that Brook's results (that is, the results in our Table 1 for $\lambda_d = 0$) apply directly to the case of over-fitted models.

The latter results, which suggest that $c^* = 2$ (approximately) regardless of the degrees of freedom, have obvious practical appeal. They offer a simple prescription to be followed in empirical work. However, as our results show, this prescription is dangerously misleading if the model is under-specified. It would be helpful to have a substitute prescription in the face of possible such model mis-specification. Table 1 does not provide this, given that λ_d is generally unknown.

If an upper bound, $\bar{\lambda}_d$, could be placed on λ_d, then the following generalised mini-max regret criterion might be considered: for some value of c, take a sequence of R^L values for $\lambda_d \in [0,\bar{\lambda}_d]$, and a corresponding sequence of R^U values. Then, vary c to c^{**}, say, to equate $\sup_{0<\lambda_d<\bar{\lambda}_d}(R^U)$ and $\sup_{0<\lambda_d<\bar{\lambda}_d}(R^L)$. It is readily shown that c^{**} is unique. The implications of such a criterion are illustrated in Table 2, where α^{**} is the test size corresponding to c^{**}, based on the central F distribution. The difficulty is that if $\bar{\lambda}_d$ is unknown, then $c^{**} \to 0$ as $\bar{\lambda}_d \to \infty$, and the optimal strategy is to apply OLS rather than pre-test. This is consistent with the results in Table 1, of course.

In the context of a mini-max regret approach to the choice of c^*, it seems that little more can be offered by way of a truly general prescription, other than to remark that the correct specification of the initial model is of

paramount importance. Of course, this applies more generally than simply to the choice of c. Under-fitting the model has other serious implications for the properties of pre-test strategies, as is illustrated by Ohtani (1983) and Mittelhammer (1984), for example.

REFERENCES

Bancroft, T.A. (1944), "On Biases in Estimation Due to the Use of Preliminary Tests of Significance," Journal of the American Statistical Association, 15, 190-204.

Bancroft, T.A. and Han, C-P. (1983), "A Note on Pooling Variances," Journal of the American Statistical Association, 78, 981-983.

Brook, R.J. (1976), "On the Use of a Regret Function to Set Significance Points in Prior Tests of Estimation," Journal of the American Statistical Association, 71, 126-131.

Cohen, A. (1965), "Estimates of the Linear Combinations of Parameters in the Mean Vector of a Multivariate Distribution," Annals of Mathematical Statistics, 36, 78-87.

Davies, R.B. (1980), "The Distribution of a Linear Combination of χ^2 Random Variables (Algorithm AS 155)," Applied Statistics, 29, 323-333.

Giles, D.E.A. (1986), "Preliminary Test Estimation in Misspecified Regressions," Economics Letters, 21, 325-328.

Giles, D.E.A. and Clarke J.A. (1989), "Preliminary-Test Estimation of the Scale Parameter in a Mis-Specified Regression Model," Economics Letters, 30, 201-205.

Giles, J.A. (1990), "Preliminary-Test Estimation of a Mis-Specified Linear Model with Spherically Symmetric Disturbances," Ph.D. Thesis, University of Canterbury.

Judge, G.G. and Bock, M.E. (1978), The Statistical Implications of Pre-test and Stein Rule Estimators in Econometrics, Amsterdam: North-Holland.

King, M.L. and Giles D.E.A. (1984), "Autocorrelation Pre-Testing in the Linear Model : Estimation, Testing and Prediction," Journal of Econometrics, 25, 35-48.

Mittelhammer, R.C. (1984), "Restricted Least Squares, Pre-Test, OLS and Stein Rule Estimators : Risk Comparisons Under Model Misspecification," Journal of Econometrics, 25, 151-164.

Ohtani, K. (1983), "Preliminary Test Predictor in the Linear Regression Model Including a Proxy Variable," Journal of the Japan Statistical Society, 13, 11-19.

Sawa, T. and Hiromatsu, T. (1973), "Minimax Regret Significance Points for a Preliminary Test in Regression Analysis," Econometrica, 41, 1093-1206.

Toyoda, T. and Wallace, T.D. (1975), "Estimation of Variance After a Preliminary Test of Homogeneity and Optimal Levels of Significance for the Pre-Tests," Journal of Econometrics, 3, 395-404.

Toyoda, T. and Wallace, T.D. (1976), "Optimal Critical Values for Pre-Testing in Regression," Econometrica, 44, 365-375.

Table 1. Optimal Critical Values and Their Significance Levels

		$\lambda_d=0$		$\lambda_d=1$		$\lambda_d=5$		$\lambda_d=10$		$\lambda_d=50$	
m	ν	c*	α*	c*	α*	c*	α*	c*	α*	c*	α*
1	2	1.990	0.294	0.970	0.429	0.319	0.629	0.173	0.718	0.037	0.865
	4	1.940	0.236	1.280	0.321	0.540	0.503	0.317	0.604	0.072	0.802
	8	1.910	0.204	1.530	0.251	0.840	0.386	0.540	0.483	0.140	0.718
	16	1.900	0.187	1.690	0.212	1.160	0.297	0.840	0.373	0.260	0.617
	24	1.890	0.182	1.750	0.198	1.330	0.260	1.028	0.321	0.366	0.551
	60	1.890	0.174	1.830	0.181	1.620	0.208	1.418	0.238	0.700	0.406
	120	1.890	0.172	1.860	0.175	1.746	0.189	1.621	0.205	1.030	0.312
2	2	2.090	0.324	1.020	0.495	0.327	0.754	0.176	0.850	0.037	0.964
	4	2.000	0.250	1.328	0.361	0.558	0.611	0.320	0.743	0.073	0.931
	8	1.960	0.203	1.558	0.268	0.860	0.459	0.550	0.597	0.141	0.871
	16	1.930	0.177	1.710	0.212	1.180	0.333	0.850	0.446	0.263	0.772
	24	1.920	0.168	1.770	0.192	1.350	0.278	1.040	0.369	0.369	0.695
	60	1.910	0.157	1.850	0.166	1.630	0.204	1.430	0.247	0.710	0.496
	120	1.900	0.154	1.870	0.159	1.760	0.176	1.630	0.200	0.040	0.357
4	4	2.060	0.251	1.360	0.386	0.564	0.704	0.326	0.848	0.075	0.986
	8	1.990	0.189	1.583	0.269	0.871	0.521	0.557	0.700	0.144	0.961
	16	1.960	0.149	1.740	0.190	1.200	0.349	0.865	0.506	0.268	0.894
	24	1.950	0.135	1.800	0.162	1.378	0.271	1.060	0.398	0.375	0.824
	60	1.940	0.115	1.880	0.126	1.662	0.171	1.460	0.226	0.727	0.577
	120	1.940	0.108	1.910	0.113	1.790	0.135	1.660	0.164	1.060	0.379
8	8	2.020	0.170	1.611	0.258	0.887	0.565	0.567	0.780	0.146	0.993
	16	1.990	0.115	1.765	0.159	1.220	0.348	0.880	0.553	0.272	0.966
	24	1.980	0.094	1.826	0.121	1.397	0.248	1.077	0.411	0.381	0.920
	60	1.970	0.066	1.910	0.075	1.690	0.119	1.480	0.184	0.738	0.658
	120	1.970	0.056	1.936	0.061	1.820	0.080	1.690	0.108	1.075	0.385
16	16	2.007	0.087	1.784	0.129	1.231	0.341	0.887	0.593	0.274	0.993
	24	1.999	0.061	1.843	0.085	1.408	0.218	1.087	0.416	0.384	0.974
	60	1.989	0.029	1.923	0.036	1.703	0.071	1.490	0.134	0.745	0.738
	120	1.986	0.019	1.953	0.022	1.832	0.034	1.701	0.055	1.083	0.379
24	24	2.005	0.048	1.850	0.070	1.413	0.202	1.090	0.417	0.385	0.988
	60	1.994	0.016	1.930	0.021	1.709	0.048	1.495	0.106	0.746	0.783
	120	1.991	0.008	1.958	0.010	1.838	0.017	1.706	0.032	1.086	0.370
60	60	2.021	0.004	1.955	0.005	1.731	0.018	1.514	0.055	0.754	0.861
	120	2.011	0.001	1.978	0.001	1.856	0.002	1.723	0.006	1.096	0.332
120	120	2.010	0.000	1.977	0.000	0.856	0.000	1.723	0.002	1.095	0.310

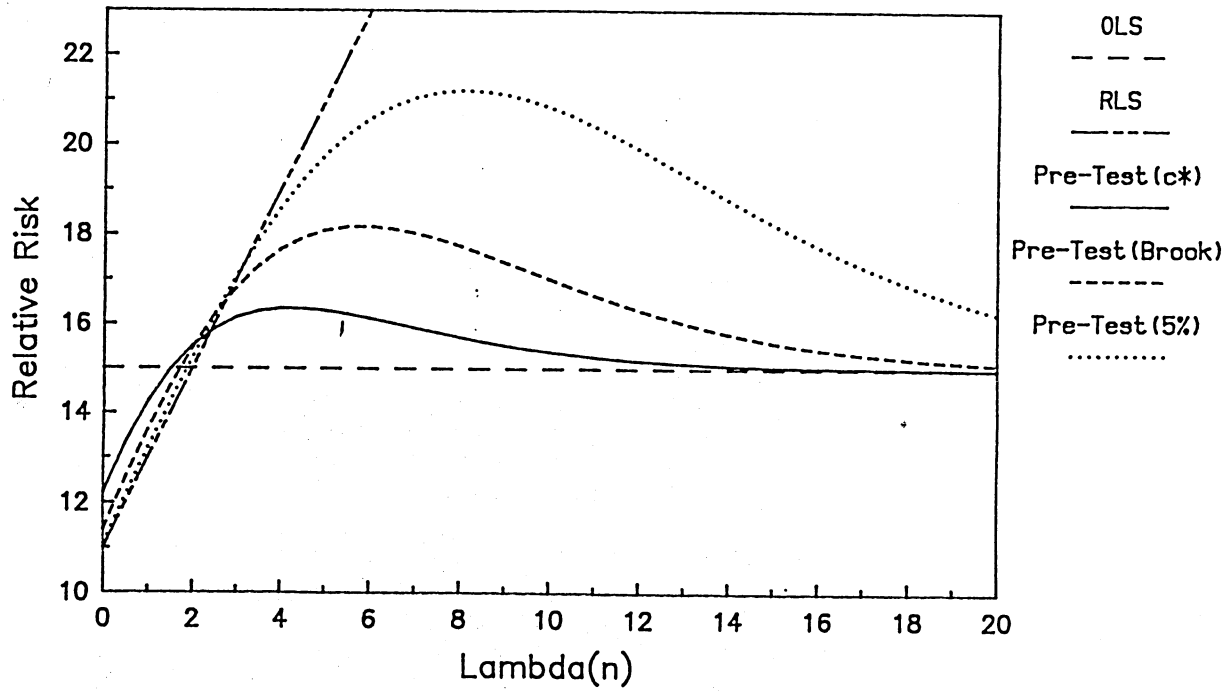
Table 2. Globally Optimal Critical Values and Their Significance Levels

		$\bar{\lambda}_d$							
		20		50		100		500	
m	ν	c^{**}	α^{**}	c^{**}	α^{**}	c^{**}	α^{**}	c^{**}	α^{**}
4	16	0.858	0.510	0.471	0.756	0.262	0.898	0.056	0.944
8	16	0.893	0.544	0.498	0.840	0.275	0.965	0.059	1.000
4	60	1.417	0.239	1.049	0.390	0.732	0.574	0.202	0.936
8	60	1.450	0.195	1.077	0.391	0.766	0.633	0.210	0.988

FIGURE 1

RELATIVE RISK FUNCTIONS

(Lambda(d)=5; m=4; v=16; k=5)



NOTE : Brook's c=1.96; 5% c=3.01; c*=1.2

LIST OF DISCUSSION PAPERS*

No. 8401 Optimal Search, by Peter B. Morgan and Richard Manning.

No. 8402 Regional Production Relationships During the Industrialization of New Zealand, 1935-1948, by David E. A. Giles and Peter Hampton.

No. 8403 Pricing Strategies for a Non-Replenishable Item Under Variable Demand and Inflation, by John A. George.

No. 8404 Alienation Rights in Traditional Maori Society, by Brent Layton.

No. 8405 An Engel Curve Analysis of Household Expenditure in New Zealand, by David E. A. Giles and Peter Hampton.

No. 8406 Paying for Public Inputs, by Richard Manning, James R. Markusen, and John McMillan.

No. 8501 Perfectly Discriminatory Policies in International Trade, by Richard Manning and Koon-Lam Shea.

No. 8502 Perfectly Discriminatory Policy Towards International Capital Movements in a Dynamic World, by Richard Manning and Koon-Lam Shea.

No. 8503 A Regional Consumer Demand Model for New Zealand, by David E. A. Giles and Peter Hampton.

No. 8504 Optimal Human and Physical Capital Accumulation in a Fixed-Coefficients Economy, by R. Manning.

No. 8601 Estimating the Error Variance in Regression After a Preliminary Test of Restrictions on the Coefficients, by David E. A. Giles, Judith A. Mikolajczyk and T. Dudley Wallace.

No. 8602 Search While Consuming, by Richard Manning.

No. 8603 Implementing Computable General Equilibrium Models: Data Preparation, Calibration, and Replication, by K. R. Henry, R. Manning, E. McCann and A. E. Woodfield.

No. 8604 Credit Rationing: A Further Remark, by John G. Riley.

No. 8605 Preliminary-Test Estimation in Mis-Specified Regressions, by David E. A. Giles.

No. 8606 The Positive-Part Stein-Rule Estimator and Tests of Linear Hypotheses, by Aman Ullah and David E. A. Giles.

No. 8607 Production Functions that are Consistent with an Arbitrary Production-Possibility Frontier, by Richard Manning.

No. 8608 Preliminary-Test Estimation of the Error Variance in Linear Regression, by Judith A. Clarke, David E. A. Giles and T. Dudley Wallace.

No. 8609 Dual Dynamic Programming for Linear Production/Inventory Systems, by E. Grant Read and John A. George.

No. 8610 Ownership Concentration and the Efficiency of Monopoly, by R. Manning.

No. 8701 Stochastic Simulation of the Reserve Bank's Model of the New Zealand Economy, by J. N. Lye.

No. 8702 Urban Expenditure Patterns in New Zealand, by Peter Hampton and David E. A. Giles.

No. 8703 Preliminary-Test Estimation of Mis-Specified Regression Models, by David E. A. Giles.

No. 8704 Instrumental Variables Regression Without an Intercept, by David E. A. Giles and Robin W. Harrison.

No. 8705 Household Expenditure in Sri Lanka: An Engel Curve Analysis, by Mallika Dissanayake and David E. A Giles.

No. 8706 Preliminary-Test Estimation of the Standard Error of Estimate in Linear Regression, by Judith A. Clarke.

No. 8707 Invariance Results for FIML Estimation of an Integrated Model of Expenditure and Portfolio Behaviour, by P. Dorian Owen.

No. 8708 Social Cost and Benefit as a Basis for Industry Regulation with Special Reference to the Tobacco Industry, by Alan E. Woodfield.

No. 8709 The Estimation of Allocation Models With Autocorrelated Disturbances, by David E. A. Giles.

No. 8710 Aggregate Demand Curves in General-Equilibrium Macroeconomic Models: Comparisons with Partial-Equilibrium Microeconomic Demand Curves, by P. Dorian Owen.

No. 8711 Alternative Aggregate Demand Functions in Macro-economics: A Comment, by P. Dorian Owen.

No. 8712 Evaluation of the Two-Stage Least Squares Distribution Function by Imhof's Procedure by P. Cribbett, J. N. Lye and A. Ullah.

No. 8713 The Size of the Underground Economy: Problems and Evidence, by Michael Carter.

(Continued on back cover)

No. 8714 A Computable General Equilibrium Model of a Fisherine Method to Close the Foreign Sector, by Ewen McCann and Keith Mclaren.

No. 8715 Preliminary-Test Estimation of the Scale Parameter in a Mis-Specified Regression Model, by David E. A. Giles and Judith A. Clarke.

No. 8716 A Simple Graphical Proof of Arrow's Impossibility Theorem, by John Fountain.

No. 8717 Rational Choice and Implementation of Social Decision Functions, by Manimay Sen.

No. 8718 Divisia Monetary Aggregates for New Zealand, by Ewen McCann and David E. A. Giles.

No. 8719 Telecommunications in New Zealand: The Case for Reform, by John Fountain.

No. 8801 Workers' Compensation Rates and the Demand for Apprentices and Non-Apprentices in Victoria, by Pasquale M. Sgro and David E. A. Giles.

No. 8802 The Adventures of Sherlock Holmes, the 48% Solution, by Michael Carter.

No. 8803 The Exact Distribution of a Simple Pre-Test Estimator, by David E. A. Giles.

No. 8804 Pre-testing for Linear Restrictions in a Regression Model With Student-t Errors, by Judith A. Clarke.

No. 8805 Divisia Monetary Aggregates and the Real User Cost of Money, by Ewen McCann and David Giles.

No. 8806 The Management of New Zealand's Lobster Fishery, by Alan Woodfield and Pim Borren.

No. 8807 Poverty Measurement: A Generalization of Sen's Result, by Prasanta K. Pattanaik and Manimay Sen.

No. 8808 A Note on Sen's Normalization Axiom for a Poverty Measure, by Prasanta K. Pattanaik and Manimay Sen.

No. 8809 Budget Deficits and Asset Sales, by Ewen McCann.

No. 8810 Unorganized Money Markets and 'Unproductive' Assets in the New Structuralist Critique of Financial Liberalization, by P. Dorian Owen and Otton Solis-Fallas.

No. 8901 Testing for Financial Buffer Stocks in Sectoral Portfolio Models, by P. Dorian Owen.

No. 8902 Provisional Data and Unbiased Prediction of Economic Time Series by Karen Browning and David Giles.

No. 8903 Coefficient Sign Changes When Restricting Regression Models Under Instrumental Variables Estimation, by David E. A. Giles.

No. 8904 Economies of Scale in the New Zealand Electricity Distribution Industry, by David E. A. Giles and Nicolas S. Wyatt.

No. 8905 Some Recent Developments in Econometrics: Lessons for Applied Economists, by David E. A. Giles.

No. 8906 Asymptotic Properties of the Ordinary Least Squares Estimator in Simultaneous Equations Models, by V. K. Srivastava and D. E. A. Giles.

No. 8907 Unbiased Estimation of the Mean Squared Error of the Feasible Generalised Ridge Regression Estimator, by V. K. Srivasatva and D. E. A. Giles.

No. 8908 An Unbiased Estimator of the Covariance Matrix of the Mixed Regression Estimator, by D. E. A. Giles and V. K. Srivastava.

No. 8909 Pre-testing for Linear Restrictions in a Regression Model with Spherically Symmetric Disturbances, by Judith A. Giles.

No. 9001 The Durbin-Watson Test for Autocorrelation in Nonlinear Models, by Kenneth J. White.

No. 9002 Determinants of Aggregate Demand for Cigarettes in New Zealand, by Robin Harrison and Jane Chetwyd.

No. 9003 Unemployment Duration and the Measurement of Unemployment, by Manimay Sengupta.

No. 9004 Estimation of the Error Variance After a Preliminary-Test of Homogeneity in a Regression Model with Spherically Symmetric Disturbances, by Judith A. Giles.

No. 9005 An Expository Note on the Composite Commodity Theorem, by Michael Carter.

No. 9006 The Optimal Size of a Preliminary Test of Linear Restrictions in a Mis-specified Regression Model, by David E. A. Giles, Offer Lieberman, and Judith A. Giles.

* Copies of these Discussion Papers may be obtained for $4 (including postage, price changes occasionally) each by writing to the Secretary, Department of Economics, University of Canterbury, Christchurch, New Zealand.