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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.

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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:

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

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,

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

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

$$\rho\left(X\hat{\beta},E(y)\right) = \left(k+2\lambda_d+(4\lambda_n-m)P_2-2\lambda_nP_4\right) \quad (2.5)$$

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

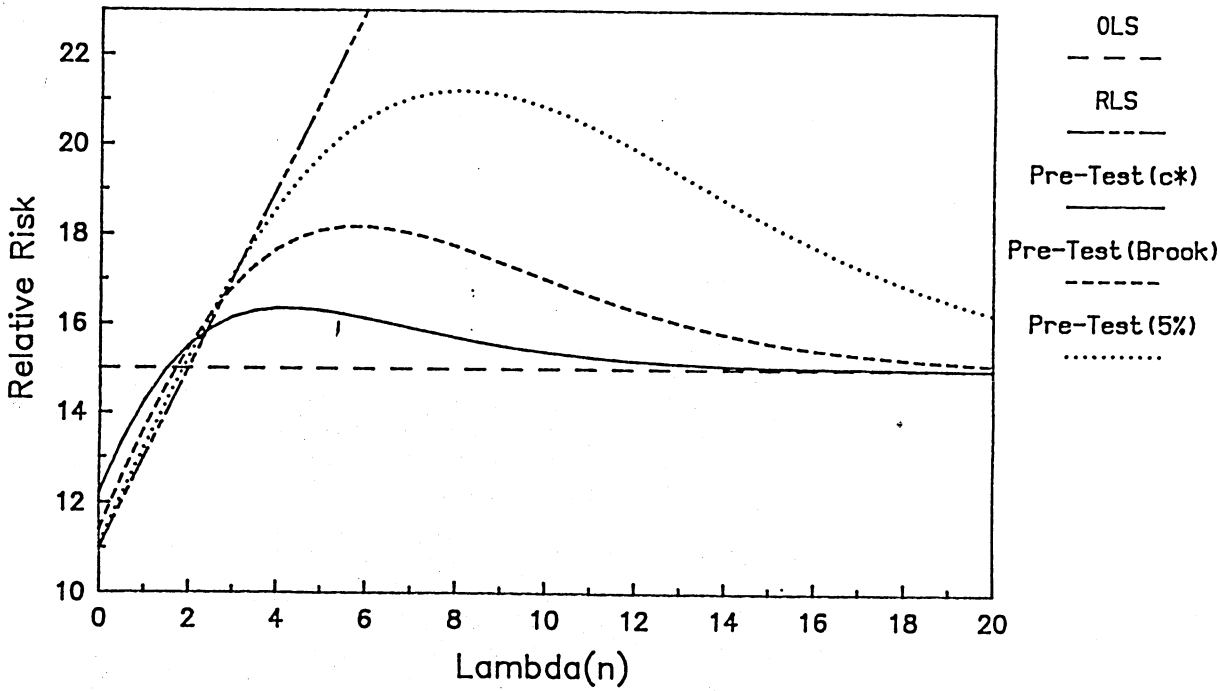
Table 2. Globally Optimal Critical Values and Their Significance Levels

		$\bar{\lambda}_d$							
		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

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