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CONTRIBUTIONS TO BOOKS

- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

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- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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ORDINARY LEAST SQUARES METHOD AND ITS VARIANTS

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ABSTRACT

Under certain assumptions, ordinary least squares (OLS) method has some very attractive statistical properties that have made it one of the most powerful and popular method in regression analysis. OLS estimators of the regression coefficients are the best linear unbiased estimators (BLUE). What happens to the properties of the OLS estimators when one or more of the assumptions are not fulfilled and what can be done in those situations? This paper describes about violations of some of assumptions in single equation linear model only. First the concept of multicollinearity is reviewed from many non-traditional angles and measures are then suggested to quantify it. Then it is proposed in this paper that one may use in the face of multicollinearity: (i) Ridge Regression (RR), (ii) Principal Component Regression (PCR) or (iii) Generalized Inverse Regression (GIR) only.

KEYWORDS

Multicollinearity, Ridge, Principal Components and Generalized Inverse Regressions, Two Famous Controversies about Credits of Discoveries.

INTRODUCTION

A very important problem in mathematical statistics is that of finding the best linear or non-linear regression to express the relationship between a dependent variable and several explanatory variables. The best solution of all problems in linear regression depends upon the distribution of the random errors. The method of least squares is the best method of fitting a regression equation.

Singh (2010 a) discussed that researchers in astronomy must be thankful for giving a new direction to their works, which latter evolved into the method of least squares. It is intriguing to notice that this method was in frequent use since the 18th century mainly on the ground of simplicity and ease of computation. Controversy about the credit arose between Gauss and Legendre in Statistics over the discovery of the method of least squares (LS). Gauss has been using it since around 1794 without bothering to publish it and Legendre published it in 1805. The most famous priority dispute in the history of Statistics is given by Stigler (1981). According to him, 'The method of OLS is the automobile of modern statistical analysis: despite its limitations, occasional accidents, and incidental pollution, it and its numerous variations, extensions, and related conveyances carry the bulk of statistical analyses, and are known and valued by nearly all. It is unnecessary to repeat the details of this dispute – R. L. Placket (1972) has done a masterful job of presenting and summarizing the evidence in the case'. A number of responsible scholars wrote volumes on the dispute and tried to settle it on the basis of morality, ethics and available letter exchanged among Gauss, Legendre, Jacobi, etc. Singh (2010 and 2011) found the famous dispute between Gauss and Legendre in Statistics over the discovery of the method of LS that who should take the credit about discovery?

Let us investigate that some of the assumptions do not follow and thus they are violated. This paper describes the application of RR, PCR and GIR only for the estimation of parameter vector in these situations.

VIOLATIONS OF ASSUMPTIONS

Violations of assumption of non-zero mean of disturbances are not very critical from computational and practical viewpoint because it affects only the intercept term of the regression and we cannot estimate the original intercept. However, since in practice the intercept term is generally of little importance, we may not pay much attention to it. The violation of assumption of normality of U leads to the case of non-normal disturbance. In this case it can be shown that the LS estimators are still BLUE and they tend to be normally distributed as the sample size increases indefinitely. However, this is not true for the small samples. In the later situation one cannot assess their statistical properties by the usual tests of significance such as t, F etc. because they are based on the assumption of normality. We can, however, use the 'Central Limit Theorem' for non-normal situation. Schmidt (1976) made some interesting observations in case of non-normal distribution of disturbance vector provided the variance of the disturbance terms is finite. Normality assumption does not seem absolutely essential if we require estimation only. Non-normality of the disturbance vector does not destroy the property of BLUE. Thus, violation of normality assumption is not so serious.

THE CASE OF HETEROSCEDASTIC DISTURBANCE

Violation of the assumption of homoscedasticity is known as heteroscedasticity. There are several reasons for the heteroscedasticity. Presence of heteroscedasticity does not destroy the unbiassedness and consistency properties of the usual OLS estimators but the estimators are not efficient. The confidence interval based on them will be unnecessarily wide and the tests of significance would be less powerful. Therefore, it will be better to detect the existence of heteroscedasticity in the data and treat them, if found. White (1980) advised to test directly for the presence of heteroscedasticity. If found should be treated. OLS estimators in those cases are the unbiased but less efficient (has higher variance) than weighted least squares (WLS) estimator. Confidence interval derived in the presence of heteroscedasticity is unnecessarily wide, the tests of significance are less powerful for OLS estimation and the prediction would be unreliable because the high variance of the predicted (estimated) value includes the variance of the disturbance term and have the parameter estimates, which are not minimal due to incidence of heteroscedasticity. Park (1966), Goldfeld and Quandt (1965, 1972), Glejser (1969) and others suggested tests which could fruitfully be applied to get information on the presence of heteroscedasticity in the data.

THE CASE OF AUTOCORRELATION

Kendall and Buckland (1971) defined the term, autocorrelation as the 'Correlation between members of series of observations ordered in time (as in time series data) or space (as in cross sectional data)'. Usually the errors in time series data exhibit serial correlation. Such error terms are said to be autocorrelated that is termed as violation of the assumption $E(u^i, u^j) = 0$ of the classical linear regression model. Several effects on the OLS regression procedure are to be faced due to the presence of autocorrelation in the error terms. OLS estimates of regression coefficients remain unbiased but they are inefficient (as compared with BLUEs). Therefore, the confidence intervals are unnecessary wide and the test of significance is less powerful. The estimate of the error variance $\hat{\sigma}^2$ is likely to be underestimating the true σ^2 and the variances and standard errors of the OLS estimators are likely to underestimate the true variances and standard errors. The usual t and F tests of significance are no longer valid.

Autocorrelated disturbances exhibit such a serious problem for the use of OLS. It is extremely important to test for their presence, if any. Various statistical tests are used to detect the presence of autocorrelation. Two commonly used tests to detect its presence are:

(a) Durbin-Watson d test: The test proposed by Durbin-Watson (1950, 1951) is one of the most widely used tests. This test is based on the assumption that errors in the regression model are generated by a first-order regressive process observed at equally spaced time period. This test is applied to small sample also. Durbin-Watson d statistic is as

(4) $$d = \sum_{t=2}^{n} (e_t - e_{t-1})^2 / \sum_{t=1}^{n} e_t^2$$

where e^t (t = 1, 2, …, n) are the residuals from an OLS analysis.

Durbin and Watson (1951) show that d lies between two bounds, say d^u and d^L, which do not depend upon x and if d is outside these limits a conclusion regarding the hypotheses (H^o : ρ = 0 and H^1 : ρ ≠ 0) can be reached. The decision procedure to test the hypothesis of zero autocorrelation against the alternative hypothesis of positive first order autocorrelation is if

$d < d^L$, reject H^o : ρ = 0

$d > d^u$, do not reject H^o : ρ = 0

$d^L \le d \le d^u$, the test is inconclusive.

where d^L and d^u are lower and upper limits respectively. The possible range of d suggested by Koutesoyiannis (1984) is 0 < d < 4. Durbin and Watson (1971), in their paper, suggest approximating the distribution of d by that of $a + b\, d^u$, where $a = E(d) - \sqrt{V(d)/V(d_u)}\, E(d^u)$ and $b = \sqrt{V(d)/V(d_u)}$.

The hypothesis of no autocorrelation is rejected if $d < a + b\, d^{u^o}$, where d^{u^o} is the critical value for the upper bound tabulated for the Durbin-Watson statistic. Theil and Nagar (1961) have attempted a solution at the expense of making more specific assumptions about the x variables. Henshaw (1966) proposed an accurate and conclusive test. However, this test is complicated and computationally cumbersome.

(b) The Von Neumann Ratio: Von Neumann suggests a useful theoretical test, which is known as the Von Neumann Ratio and defined by

(5) $$\delta^2 / s^2 = \frac{1}{n-1} \sum_{t=2}^{n} (e_t - e_{t-1})^2 \Big/ \frac{1}{n} \sum_{t=1}^{n} (e_t - \bar{e})^2$$

This is a ratio of mean square successive difference to variance. In OLS application $\bar{e}$ = 0. However, this is not possible because the values of the OLS residuals are not independently distributed for small samples, even if the population disturbances are independently distributed.

THE CASE OF MULTICOLLINEARITY

It is interesting to note that the problem of multicollinearity is as old as econometrics itself. Due to being near singularity of $X'X$, the OLS estimate is not obtained. However, $|X'X|$ would be quite close to zero and the variance of $\hat{\beta}$ as well as the estimate of β itself can explode. The term multicollinearity is due to Frisch (1934). The traditional solution of the multicollinearity is through 'collecting more observations' or 'dropping one or more variables', which may often be impracticable in certain situations. Hence, attempts should be made to squeeze out maximum information from whatever data one has at his disposal. First the concept of multicollinearity is reviewed from many non-traditional angles and measures are suggested to quantify it. Then it is proposed that in face of multicollinearity one may use: RR, GIR or PCR.

The ridge estimator (RE) is different from OLSE in that here a small positive increment (called biasing parameter) is made to the diagonal element of the design matrix before inverting it. However, RE is biased; it has smaller mean square error than OLSE. RE is compared with other biased estimators.

The PCR is an alternative to OLS for multicollinear data and is a method of inspecting the design matrix for the directions of variability and using this information to reduce the dimensionality of the estimation procedure. It is contended that if the purpose of analysis is prediction, components having smallest correlation with the criterion variable should be deleted if the emphasis is on multicollinearity.

Another method to combat the multicollinearity is the GI regression (GIR). Moore-Penrose and Rao's generalized inverses could lead to a unified theory of LS estimation when the design matrix is of less than full column rank. The GI estimator is biased and there exists a trade-off between bias and variance, like RE – but here the bias and variance are respectively increasing and decreasing functions of the rank of the design matrix (like biasing parameter is in case of RE). The RE and GI estimators both coincide with OLS estimator when biasing parameter is zero and the rank of the design matrix is equal to number of columns respectively.

CONSEQUENCES AND DETECTION OF MULTICOLLINEARITY

The presence of multicollinearity has a number of potentially serious effects on the least square estimates of the regression coefficients. Some of these effects may be easily demonstrated. It is true that collinearity does not destroy the property of minimum variance. But this does not mean that variance of an OLS estimator will necessary be small (in relation to the value of the estimator) in any given sample. We must see in presence of multicollinearity what happens or is likely to happen in any given samples.

For near multicollinearity, $\lambda^m \to 0$ and MSE ($\hat{\beta}$) tends to infinity, $\hat{\beta}$ is subject to vary large variance. Often this is revealed by the low values of the usual t-ratio whose denominator has the square root of the diagonal elements of $(X'X)^{-1}$, which are termed as variance inflation factor (VIF) by Marquardt (1970). Farrar and Glauber (1967) were the first to suggest looking at the values of r^{ii} to diagnose multicollinearity. Marquardt (1970) suggests a rule of thumb according to which VIF (i) = r^{ii} > 5 indicates harmful multicollinearity.

Bartlett's and Haitovsky's Chi-squares are popular tests for the detection of multicollinearity. Farrar and Glauber (1967) attempted to define a standard of comparison for $|X'X|$ by defining multicollinearity as a departure of the matrix from orthogonality. The estimates of both coefficient vector and its dispersion matrix require this operation. Working from Wishart distribution, Wilks (1932) was able to derive the moments and distribution of the determinant of the sample covariance matrix. However, Bartlett (1950) by comparing the lower moments of the Wilks distribution with those of chi-square distribution, obtained a transformation of |R| as $\chi^2 = -[n - 1 - \frac{1}{6}(2m + 5)] \log |R|$ that is distributed approximately as chi-square with $\frac{1}{2}m(m-1)$ degrees of freedom,

where n = size of the sample and m = number of variables. A high value of χ^2 indicates the existence of multicollinearity. Cooley and Lohnes (1971) have reported on a Monte Carlo study of this test. For n = 20, m = 10, α = 0.05, one is virtually certain to reject the null hypothesis when the elements of R are larger (in absolute value) than 0.36. For n = 200, m = 10, α = 0.05, one is virtually sure to reject the null hypothesis when the elements of R are larger (in absolute value) than 0.9. A heuristic statistic, which is consistent with this concept is due to Haitovsky (1969) and is given by

(6) $$\chi^2 = [n - 1 - \frac{1}{6}(2m + 5)] \log (1 - |R|)$$

A small value of χ^2 indicates the existence of multicollinearity; its severity can be measured by the level of significance at which the null hypothesis $H^o : |R| = 0$ is accepted. Klein (1960) suggests that the multicollinearity is said to be harmful If $|r^{ij}| > R^y$ for all $i \neq j$, where r^{ij} is the zero order correlation between two predictor variables. Farrar and Glauber (1967) found some drawbacks in Klein's rule and they have developed a set of three tests for multicollinearity. The first test, based on χ^2, has been discussed above in this section. The second test is based on F test for locating which variables are multicollinear. Yet another test is a t test for finding out the pattern of multicollinearity, that is, for determining which variables are responsible for appearance of multicollinearity.

POSSIBLE SOLUTION OF MULTICOLLINEARITY PROBLEMS

When multicollinearity is present in a set of explanatory variables, the OLS estimates of the individual regression coefficients tend to be unstable and can lead to erroneous inferences. It is contended that multicollinearity essentially arises due to lack of sufficient information in the sample to permit reliable estimation of the individual parameters. In some situations it may be the cases that one is not interested in all the parameters. In such cases we can get estimates for parameters and one is interested in that have smaller mean square errors than the OLS estimators. Usually, one of the highly correlated variables may be dropped. Dropping a variable from the model to alleviate the problems of multicollinearity may lead to the specification bias. Hence, the solution may be worse than the diseases in certain cases. The traditional remedial measures for multicollinearity problem have to collect more data. This was suggested by Ragnar Frisch in his work on confluence analysis. The difficulty with the collection of more data is that it may be expensive or impracticable in many situations. One may be interested to squeeze out maximum information from whatever data he has at his disposal. This has motivated for the development of some very ingenious statistical methods, for example, the RR, GIR and PCR. These could fruitfully be applied to solve the problem. It is intended to discuss these methods in the next section. Incidentally, Frisch is considered as the Father of Econometrics. After detecting its presence, some alternative estimation methods are required to use that provides a more informative analysis of the data than the OLS method.

RIDGE REGRESSION

The technique of RR proposed by Hoerl and Kennard (1970 a, b) has become a popular tool with data analysis faced with a high degree of multicollinearity in their data. Hoerl and Kennard (H-K) have suggested adding a small positive quantity in the diagonal elements of the design matrix, $X'X$ before inverting it. In other words, instead of $\hat{\beta} = (X'X)^{-1} X'Y$, they propose $\hat{\beta}_R = (X'X + kI)^{-1} X'Y$. The genesis of ridge regression lies with a paper by Hoerl (1959) in which he discussed about the optimization from the response surface point of view. Later, Hoerl published another popularized article that explored RR as an approach to multiple linear regression involving 'poorly-conditioned' data, that is, non-orthogonal predictor variable matrices (Hoerl, 1962). The next step in the development of RR was the paper by Draper (1963) which provided the proofs lacking in Hoerl's paper. However, a rigorous statistical basis for the application of RR to the problem of multicollinearity in multiple linear regression models was developed by H-K (1970 a).

Let $\hat{\beta}_R$ is ridge estimator of β in the linear model (1). Then

(7) $$\hat{\beta}_R = (X'X + kI)^{-1} X'Y = W X'Y$$

where $W = (X'X + kI)^{-1}$ and $k \geq 0$.

RR was originally suggested as a procedure for investigating the sensitivity of least squares based on data exhibiting near extreme multicollinearity, where small perturbations in the data may produce large changes in the magnitude of the estimated coefficients. H-K (1970 a, b) introduce the GRR estimator (GRE) as

(8) $$\hat{\beta}_{GR} = [X'X + PDP']^{-1} X'Y$$

where P is the matrix whose columns are orthonormal characteristic vectors of $X'X$ and D is a diagonal matrix of constants $d^i \geq 0$. If the constants d^i are all equal and take the value $d^i = k$, the GRE reduces to the ordinary ridge estimator (ORE or RE) $\hat{\beta}_R = (X'X + kI)^{-1} X'Y$. The procedure of ORE or RE actually defines a family of estimators of which OLS estimator is a member for k = 0, i.e., with k = 0 the ORE reduces to OLS estimator.

Hawkins (1975) outlined a technique named eigenanalysis and used as estimator which is identical with RE. The data matrix D = (Y: X) could be used to form another matrix T = D'D which could be diagonalized through an orthogonal matrix A such that ATA' = diag (λ^i), where λ^i's are eigenvalues of T. Conniffe and Stone (1973) summarized criticisms on the choice of biasing parameter, k and conclude that there is no guarantee for the improvement of OLS estimators in case of a particular choice of k. They further conclude that estimate of k from the data is not a constant and status of H-K approach on choice of k is unclear. Smith, Goldstein, Conniffe and Stone (1975) did not accept the conclusion given by Conniffe and Stone on ridge estimators in 1973 and they believe that RR is a useful addition to the data analyst's tool-box.

RR is closely related to Bayesian estimation. Generally, if prior information about β can be described by a p-variable normal distribution mean vector β_o and variance-covariance matrix V_o, the Bayesian estimator of β is

(9) $$\hat{\beta}_B = [\frac{1}{\sigma^2} X'X + V_o^{-1}]^{-1} [\frac{1}{\sigma^2} X'X + V_o^{-1} \beta]$$

The use of Bayesian method in regression is discussed by many authors like Leamer (1978), Zellner (1971), etc. Two major drawbacks of this method are the data analyst must make an explicit statement about the form of the prior distribution and the statistical theory in this connection is not yet widely understood.

However, if we select prior mean $\beta_o = 0$ and $V_o = \sigma_0^2 I$, then

(10) $$\hat{\beta}_B = (X'X + kI)^{-1} X'Y \equiv \hat{\beta}_R$$

reduces to the usual ORE, when $k = \sigma^2 / \sigma_0^2$.

Much controversy concerning RR centres on the choice of the biasing parameter, k. Several authors have suggested methods for selecting the biasing parameter, k. The ORE with a given k is a linear estimator which is biased but which, for values $\hat{\beta}_R$ is a certain interval, has smaller mean square error than the OLS estimator. The optimal constant k was developed by some technique derived from intelligent systems (Genetic Algorithm) and some statistics techniques.

Zellner (1962) proposed the estimation of seemingly unrelated regression (SUR) system having unknown error covariance matrix. Moreover, Firinguetti (1997) pointed out the use of RR in the context of SUR and performed some simulation experiments. Firinguetti and Rubio (2008) discussed asymptotic properties RE and compared it with generalized LS through simulation. Although $\hat{\beta}$ is BLUE, there are a number of conditions under which the OLS estimators are fully efficient. They further discussed that analyzing multicollinearity in a context such as a system of SUR is much more complex than in the classical linear regression model, but it is expected it will adversely affect the generalized LS estimator. They concluded that RR estimators can outperform the operational generalized LS estimator having multicollinear data.

Zou and Hastie (2005) discussed that for usual n > m situations, if there are high correlations between predictors, it has been empirically observed that the prediction performance of the lasso is dominated by RR. Despite more modern approach such as boosting (Buhlmann 2006) RR, henceforth RR continues to be useful in many situations, in particular in chemometrics when it is assumed that all coefficients have approximately the same order of magnitude. Maronna and Yohai (2009) employed robust RR estimator to propose a robust estimator for functional regression based on splines.

GENERALIZED INVERSE REGRESSION

Let us a rewrite OLS estimator of β from (2) $\hat{\beta} = A^{-1} X' Y$, where $A = (X'X)^{-1}$ is a matrix, termed as the inverse of A such that $A A^{-1} = A^{-1} A = I$. From time to time, the corresponding problem in the case where A may be non-square or singular has also received attention. Accordingly, attempts were made to define an inverse with properties similar to A^{-1}, leading to concept most often termed as 'generalized inverse' or a g-inverse. The introduction of a g-inverse has made possible a unified treatment both of the theory and practice of OLS fitting to models of both full and nonfull rank cases. This is especially true with regard to multiple regression applied to analysis of variance problems where, due to conventional restriction on the ANOVA model, the $X'X$ matrix is usually singular (Draper and Smith, 1981) However, since practical OLS regression problems rarely involve singular matrices (mostly because of rounding-off errors, even singular matrices are customarily inverted by computer routines utilizing floating point arithmetic), the use of g-inverse in OLS methodology has not attracted much attention from the analysis. However, we believe g-inverse regression has great potentialities in solving the problem of multicollinearity. In least squares notation, (2) is rewritten as

(11) $$\hat{\beta}_G = (X'X)^{-} X'Y$$

where $(X'X)^{-}$ is a g-inverse of $X'X$. It is a remarkable fact that $(X'X)^{-}$ can be treated for statistical purposes almost exactly as if it were an ordinary inverse, in particular, the quantities $\hat{\beta}_G = (X'X)^{-} X'Y$ can be regarded to some extent as estimate of the parameters, and the elements of $(X'X)^{-}$ as their relative variances and covariances. The sum of squares due to regression is $\hat{\beta}_G X'Y$ in usual way, but the degrees of freedom associated with this are equal to rank of $X'X$.

The concept of g-inverse regression was, presumably, first introduced by Marquardt (1970) who started with an orthogonalized square matrix of order and rank m, i.e., S'AS = D, where $A = X'X$, S'S = I, D is the diagonal matrix of ordered eigenvalues; $\lambda^1 \geq \lambda^2 \geq \ldots \geq \lambda^m$. A^{+r} is however, a g-inverse in the Moore-Penrose sense.

(12) $$A^{+r} = \sum_{j=1}^{r} \frac{1}{\lambda_j} S_j S_j'$$ where S^j is the jth eigenvector of S^r

In practice, however, affairs are not so quite straightforward since even when the original observations (regarded as exact) are subject to exact linear relationships, rounding off errors may mean that the $X'X$ matrix is not exactly singular, even when it is, further rounding off errors are involved in forming the elements of $(X'X)^{-1}$. The g-inverse estimator is equivalent to an OLS estimator when the actual data are supplemented by a fictitious set of data points taken according to an experiment $H^r = S^{m-r}\sqrt{(-1)\ D_{m-r}}$, the response Y being set to zero for each of these supplementary data points. g-inverse of matrices has wide range of application in Statistics. Moore (1920), perhaps, made the first major contribution in this direction. Later Penrose (1955) defined g-inverse of a matrix incase of singularity and rectangularity of matrices. Penrose's approach was purely algebraic. Moore's and Penrose's definitions are quite similar – hence they are referred as Moore-Penrose g-inverse. Rao (1962, 1967) gave an inverse of a singular matrix for use in computing least square estimates of parameters in Gauss-Markov model and their variances and covariances. Rao (1962) introduced a general definition of a g-inverse in the form of $A A^{-} A = A$ and in 1967 provides a classification of g-inverses. Moore-Penrose inverse gives unique solution while Rao's g-inverse does not g-inverse estimator looks a better alternative to OLS in case of ill conditioning. The g-inverse solution is especially relevant for precisely zero eigenvalues. For detailed discussion of the different types of g-inverses, their application and generalizations, references could be made to Rao and Mitra (1971), Powel (1969), Don (1982) and Lee, Judge and Zellner (1977).

PRINCIPAL COMPONENTS REGRESSION

The PCR is a method of inspecting the sample data or design matrix for directions of variability and using this information to reduce the dimensionality of the estimation problem. The reduction in dimensionality is achieved by imposing exact linear constraints that are sample specific but have certain maximum variance properties that make their use attractive. The use of principal component estimators (PCE) as an estimating procedure in situations of may be attributed to Kendall (1957), but it has found its recent proponent in McCullum (1970). They demonstrated that Kendall's suggestion of artificial orthogonalization could help to alleviate the problem of multicollinearity in regression analysis. Leaving aside many alternative criteria for specifying PCE, he adopted that of minimizing the mean square error (MSE) of a single parameter and derived the corresponding PCE. Based on the criterion of MSE, he showed that replacement of the correlated regressors by a smaller set of their orthogonal principal components (PC) can often result in better estimation of the regression parameters than OLS estimation. In particular our evaluation formula involves only three factors: the degree of multicollinearity, the relative magnitude of the true regression coefficients, and the tolerable deviation from the true parameters. The independence of the evaluation formula from the unknown variance of the random term is not tri vial. It reduces the analyst's choice between OLS and PC estimators to manageable proposition. In case of strong multicollinearity, the use of regression on PC only hinges upon the analyst's knowledge about the approximate bounds and relative magnitudes of the true regression coefficients. The objective of PC analysis is to find a linear transformation of a sample matrix x of n observations on m variables into a new set, denoted by Z, where the new set has certain desirable properties. The new variables correspond to the principal axes of the hyperellipsoid formed by the scatter

of sample points in the m-dimensional space having the columns of x as basis. The PC transformation is, therefore, a rotation from the original x coordinate system to the system defined by the principal axes of this hyperellipsoid. The properties, which provide the rationale for using the transformed variables in certain multivariate analyses, are: (i) the columns of Z are uncorrelated with each other in the sample (orthogonality), and (ii) each principal axes progressing from $z^1, z^2, \ldots, z^m$, passes through the direction of maximum variance of x's, consistent with being orthogonal to the preceding z's.

The PC can be extracted from either a covariance or a correlation matrix. But if the units of variables are arbitrary (such as scale for tests), then it is best to work with correlation matrix. Consequently, in many instances the covariance matrix is transformed into a correlation matrix before a PC analysis is conducted. A major problem with extracting PC from a sample correlation matrix is that since we are now working with elements such as $\hat{\sigma}_{ij} / \hat{\sigma}_i \hat{\sigma}_j$ instead of $\hat{\sigma}_{ij}$, the sampling distribution theory becomes quite complex. Notice that, $\hat{\sigma}_{ij}$, $\hat{\sigma}_i$ and $\hat{\sigma}_j$ are all sample estimates. Characteristic roots and vectors play an important role in many problems of applied mathematics, dynamics and statistical theory. The numerical analysis literature contains a number of techniques for their computation. Biased estimator of regression coefficients is obtained by using a procedure known as PC regression. The OLS regression model $Y = x\beta + u$ is rewritten in terms of the components as

(13) $$Y = x\beta + u = z\alpha + u$$

We may duplicate the OLS estimator $\hat{\beta}$ of β by obtaining OLS estimate $\hat{\alpha}$ of α and applying the transformation $\hat{\beta} = A\hat{\alpha}$. The PC estimate is

(14) $$\hat{\beta}_{PC} = A^* \hat{\alpha}$$

Where $A^* = A\Delta$ is the matrix obtained by nullifying those columns of the transformed matrix A that correspond to zero elements in δ. A major problem is, 'How do one select components to delete and what are consequences of each choice'? Usually the number of PC, which are extracted from the x's is smaller than the number of the x's. Some of commonly used criteria suggested for the selection of components for deleting are: (i) Fomby, Hill and Johnson criterion (ii) Kaiser's criterion (iii) Cattell's Scree-test (iv) Bartlett's criterion and (v) Tests of hypotheses criterion. Koutsoyiannis (1984, p. 431) has given an empirical test that is actually, rather crude rule of thumb. According to this rule only the loadings which have a value (numerically) greater than 0.3 are to be retained, provided the sample contains at least 50 observations. The use of PC in regression has received wide attention in the literature in the past few years and the topic is now beginning to appear in textbooks too. However, in several recent publications the suggested rule for inclusion is simply based on the variance of the component, i.e. to retain components with large variances and reject those with small variances. Nevertheless, various authors, including Kendall (1957), Jeffers (1967), Massey (1965) and Hawkins (1973) recommended transferring to PC and deleting components with small variances. Mosteller and Tukey (1977, pp. 397 - 398) argue that 'the components with small variance are unlikely to be important in regression, apparently on the basis that nature is tricky, but not downright mean'. On the other hand, Jeffers (1967, p. 230) specially states that the relationship between the dependent variable and all of the components should be examined since it is always possible that one of the components with small variance may be related to the dependent variable. The idea of using PC in regression is not new. Kendall (1957) suggested it in his book on Multivariate Analysis, as did Hotelling (1957) in his paper. Farebrother (1972), Greenberg (1975), Hill, Fomby and Johnson (1977), Johnson, Reimer and Rothrock (1973), Lott (1973) and Massey (1965) used the case of PC regression as a method dealing with ill-condition data.

Pasha, Shah and Ghosia (2004) adopted an unconventional method of PCR for the solution of multicollinearity. They showed some fairly precise estimates of coefficients by the use of this technique and claimed that property of PCR makes it superior to the OLS in case of multicollinear data. Tarvainen et al. (2007) proposed a PCR based method for estimating R- and T-waves (RT) variability. The main benefit of this method is that it does not necessitate T-wave detection. They observed estimate of RT variability accurately and to be less sensitive to noise than the traditional methods exercising on electrocardiogram recordings. The method is simple to apply but it does not directly give absolute values of RT interval.

CONCLUDING REMARKS

The violation of assumptions of normality and zero mean of disturbances do not affect seriously the estimate under OLS. The violation of assumption of homoscedasticity does not destroy the unbiasedness and consistency properties of the usual OLS estimators but estimators are not efficient. The confidence intervals based on them will be unnecessarily wide and tests of significance would be less powerful. White (1980) advised to test directly for the presence of heteroscedasticity and treat them if found. The straightforward method of resolving the problem of heteroscedasticity is by means of the weighted least squares in case of known heteroscedastic variances. It will be better to apply estimated generalized least squares when the form of heteroscedasticity is not known.

Autocorrelation is a problem generally encountered with time series data and it usually does not occur in studies using cross-sectional data. The OLS estimators are unbiased as well as consistent in the presence of autocorrelation but they are no longer efficient. As a result the usual t and F tests of significance can not be legitimately applied. The consequences of autocorrelation are serious for the estimates and the standard errors of the estimates of the parameter vectors.

Multicollinearity is a usual problem under study dealing with several explanatory variables. As a result, the parameter vector is not estimable precisely. The adequate attention is required to give on the problem of multicollinearity after its detection and its solution through some variants of OLS, because it is felt that the traditional solution through 'collecting more observations' and 'dropping few variables' may often be impracticable. Hence, an attempt should be made to squeeze out maximum information from whatever data we have in our possession and this interest has motivated the researchers to the development of some ingenious statistical methods: RR, GIR and PCR. Solution of the problem of multicollinearity is done successfully with the application of above statistical methods. The ridge estimator (RE) is different from OLS estimator in that a small positive increment (called biasing parameter) is made to the diagonal elements of the design matrix before inverting it. Though RE is biased (but there exists a trade-off between bias and variance through the biasing parameter), it has smaller mean square error than OLS estimator.

The PCR is a method of inspecting design matrix for directions of variability and using this information to reduce the dimensionality of the estimation procedure. It is contended that if the purpose of analysis is prediction, components having smallest correlation with the criterion variable should be deleted while components with smallest eigenvalues should be deleted if the emphasis is on multicollinearity.

Yet another method discussed to combat the multicollinearity is the GIR. After discussing Moore-Penrose and Rao's generalized inverses, a discussion is presented as to how these could lead to a unified theory of least squares estimation when the design matrix is of less than full column rank. The GI estimator is biased and there exists a trade-off between bias and variance, like RE – but here the bias and variance are respectively increasing and decreasing functions of the rank of design matrix (like biasing parameter is in case of RE). The RE and GIR estimators both coincide with OLS estimator when the biasing parameter is zero and the rank of design matrix is equal to number of columns respectively.

Singh's (2011) discussion on giving credit to Gauss and not to Legendre for the discovery of the method of LS seems to be an appropriate and legitimate. Similarly, it is highly appropriate and legitimate to give credit to Tychonoff 's TR and not to Hoerl and Kennard on discovery of RR because of Tychonoff 's TR is more general nature than H-K's RR which is highly contextual in nature.

REFERENCES

1. --------- (1970 b), "Ridge Regression: Application to Nonorthogonal Problems", Technometrics, 12 (1), 69-82.
2. --------- (1972), "Nonlinear Methods in Econometrics", North Holland Publishing Co., Amsterdam.
3. --------- (2010 b), "A Survey of Ridge Regression for Improvement Over Ordinary Least Squares", The IUP Journal of Computational Mathematics, III (4), 1-21.

4. Bartlett M S (1950), "Tests of Significance in Factor Analysis", British Journal of Psychology, Statistical Section 3, 77 - 85.
5. Buhlmann P (2006), "Boosting for High-Dimensional Linear Models", The Annals of Statistics, 34 (2), 559 -583.
6. Conniffe D and Stone J (1973), "A Critical View of Ridge Regression", The Statistician, 22 (3), 181 -187.
7. Cooley W M and Lohnes P R (1971), "Multivariate Data Analysis", John Wiley an Sons, Inc., New York.
8. Don F J H (1982), "Restrictions on variables", Journal of Econometrics, 18 (3), 369-393.
9. Draper N R (1963), "Ridge Analysis of Response Surveys", Technometrics, 5 (4), 469-479.
10. Draper N R and Smith H (1981), "Applied Regression Analysis", John Wiley and Sons, Inc., New York.
11. Durbin J and Watson G S (1950), "Testing for Serial Correlation in Least Squares Regression I", Biometrika, 37 (3/4), 409-428.
12. Durbin J and Watson G S (1951), "Testing for Serial Correlation in Least Squares Regression II", Biometrika, 38 (1/2), 159-178.
13. Durbin J and Watson G S (1971), "Testing for Serial Correlation in Least Squares Regression III", Biometrika, 58 (1), 1-19.
14. Farebrother R W (1972), "Principal Component Estimators and Minimum Mean Square Criteria in Regression Analysis", Review of Economics and Statistics, 54 (3), 332 - 336.
15. Farrar D E and Glauber R R (1967), "Multicollinearity in Regression Analysis: The Problem Revisited", The Review of Economics & Statistics, 49 (1), 92-107.
16. Firinguetti L (1997), "Ridge Regression in the context of Seemingly Unrelated Regression Equations", Journal of Statistical Computation and Simulation, 56 (2), 145 -162.
17. Firinguetti L and H. Rubio (2008), "Some Asymptotic Properties of Ridge Regression in a System of Seemingly Unrelated Regression Equations", Communication in Statistics – Theory and Methods, 37 (15), 2433 -2446.
18. Frisch R (1934), "Statistical Confluence Analysis by Means of Complete Regression Systems", Institute of Economics, Oslo University, Publication No. 5, cited in Singh (2010 b).
19. Glejser H (1969), "A New Tests for Heteroscedasticity", JASA, 64 (325), 316-323.
20. Goldfeld S M and Quandt R E (1965), "Some Tests for Homoscedasticity, JASA, 60 (310), 539-547.
21. Greenberg E (1975), "Minimum Variance Properties of Principal Component Regression", JASA, 70 (349), 194-197.
22. Haitovsky Y (1969), "Multicollinearity in Regression Analysis: Comment", Review of Economics & Statistics, 51 (4), 486- 489.
23. Hawkins D M (1973), "On the Investigation of Alternative Regression by Principal Component Analysis", Applied Statistics, 22 (3), 275-286.
24. Hawkins D M (1975), "Relation between Ridge Regression and Eigenanalysis of the Augmented Correlation Matrix", Technometrics, 17 (3), 477- 480.
25. Henshaw R C (1966), "Testing Single-Equation Least-Squares Regression Model for Autocorrelated Disturbances", Econometrica, 34 (3), 646-660.
26. Hill R C, T. B. Fomby and S. R. Johnson (1977), "Component Selection Norms for Principal Components Regression", Communications in Statistics, A, 6 (14), 837-846.
27. Hoerl A E (1959), "Optimum Solution of Many Variables Equations", Chemical Engineering Progress, 55, Nov., 69-78, cited in Singh (2010 a).
28. Hoerl A E (1962), "Application of Ridge Analysis to Regression Problems", Chemical Engineering Progress, 60, 54 - 59.
29. Hoerl A E and Kennard R W (1970 a & 2000), "Ridge Regression: Biased Estimation of Nonorthogonal Problems", Technometrics, 12 (1), 55-67.
30. Hotelling H (1957), "The Relations of the Newer Multivariate Statistical Methods to Factor Analysis", British Journal of Statistical Psychology, 10, 69-79.
31. Jeffers J N R (1967), "Two Case Studies in the Application of Principal Component Analysis", Applied Statistics, 16 (3), 225-236.
32. Johnson S R, Reimer S C and Rothrock T P (1973), "Principal Components and the Problem of Multicollinearity", Metroeconomica, 25 (3), 306-317.
33. Kendall M G (1957), "A Course in Multivariate Analysis", Hafner Publishing Inc., New York.
34. Kendall M G and Buckland W R (1971), "A Dictionary of Statistical Terms", Hafner Publishing Inc., New York.
35. Klein L R (1960), "Essays in Economics and Econometrics", University ofNorth Carolina Press, Chapel Hill, N. C.
36. Koutesoyiannis A (1984), "The Theory of Econometrics", Macmillan Publishing Inc., New York.
37. Leamer E (1978), "Specification Searches: Ad Hoc Inference With Nonexperimental Data", John Wiley & Sons, Inc., New York.
38. Lee T C, Judge G G and Zellner A (1977), "Estimating the Parameters of the Markov Probability Model from Aggregate Time Series Data", 2nd Ed., North-Holland Publishing Company, Amsterdam.
39. Lott W F (1973), "The Optimal Set of Principal Components Restrictions on a Least Squares Regression", Communications in Statistics, A2, 449 - 464.
40. Maronna R A and Yohai V J (2009), "Robust Functional Linear Relation Based on Splines", Available at http:// mate.unlp.edu.ar/publicaciones/23112009231134.pdf.
41. Marquardt D W (1970), "Generalized Inverses, Ridge regression: Biased Linear Estimation and Non-linear Estimation", Technometrics, 12 (3), 591-612.
42. Massey W F (1965), "Principal Component Regression in Exploratory Research", JASA, 60 (309), 234 -256.
43. McCullum B T (1970), "Artificial Orthogonalization in Regression Analysis", Review of Economics and Statistics, 52 (1), 110-113.
44. Moore E H (1920), "On the Reciprocal of the General Algebraic Matrices (Abstract)", Bulletin of the American Mathematical society, 26 (9), 394- 395.
45. Mosteller F and Tukey J W (1977), "Data Analysis and Regression: A Second Course in Statistics", Reading, Mass: Addition-Wesley.
46. Park R E (1966), "Estimation with Heteroscedastic Error terms", Econometrica, 34 (4), 888.
47. Pasha G R, Shah M A A and Ghosia (2004), "Estimation and Analysis of Regression Coefficients When Explanatory Variables are Correlated", Journal of Research (Science), 15 (1), 33 -39.
48. Penrose R (1955), "A Generalized Inverse for Matrices", Proceedings of the Cambridge Philosophical Society, 51, 406 - 413.
49. Plackett R L (1972), "The Discovery of the Method of Least Squares", Biometrika, 59 (2), pp. 239 – 251.
50. Powell A (1969), "Aitken Estimators as a Tool in Allocating Predetermined Aggregates", JASA, 64 (327), 913 - 922.
51. Rao C R (1962), "A Note on a Generalized Inverse of a Matrix with applications to Problems in Mathematical Statistics", Journal of the Royal Statistical Society (B), 24 (1), 152-158.
52. Rao C R (1967), "Calculus of Generalized Inverses of Matrices: Part I- General Theory, Sankhya (A), 29 (3), 317-342.
53. Rao C R and Mitra S K (1971), "Generalized Inverse of Matrices and Its Applications", John Wiley and sons, Inc., New York.
54. Schmidt P (1976), "Econometrics", Marcel Dekker, New York.
55. Singh R (2010 a), "Development of Least Squares: A Survey", The IUP Journal of Computational Mathematics, III (1), 54-84.
56. Singh R (2011), "Two Famous Conflicting Claims in Econometrics", Asian-African Journal of Economics and Econometrics, 11 (1), 185 - 186.
57. Smith A F M, Goldstein M, Conniffe D and Stone J (1975), "Ridge Regression: Some Comments on a Paper of Conniffe and Stone", The Statistician, 24 (1), 61 - 68.
58. Stigler S M (1981), "Gauss and the Invention of Least Squares", The Annals of Statistics, 9 (3), 465 - 474.
59. Tarvainen M P, Laitinen T, Laitinen T L, Niskanen J P and Karjalainen P A (2007), "Principal Components Regression Approach for Estimating Ventricular Repolarization Duration Variability", EURASIP Journal on Advances in Signal Processing, 1-10, doi:10.1155/2007/58358.
60. Theil H and Nagar A R (1961), "Testing Independence of Regression Disturbances", JASA, 56 (296), 793-806.
61. White H (1980), "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity", Econometrica, 48 (4), 817-838.
62. Wilks S S (1932), "Certain Generalizations in the Analysis of Variance", Biometrika, 24 (3/4), 471- 494.
63. Zellner A (1962), "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias", JASA, 57 (298), 348 -368.
64. Zellner A (1971), "An Introduction to Bayesian Inferences in Econometrics", John Wiley & Sons, Inc., New York.
65. Zou H and Hastie T (2005), "Regularization and Variable Selection via the Elastic Net", Journal of the Royal Statistical Society (B), 67 (2), 301-320.

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In this age of Commerce, Economics, Computer, I.T. & Management and cut throat competition, a group of intellectuals felt the need to have some platform, where young and budding managers and academicians could express their views and discuss the problems among their peers. This journal was conceived with this noble intention in view. This journal has been introduced to give an opportunity for expressing refined and innovative ideas in this field. It is our humble endeavour to provide a springboard to the upcoming specialists and give a chance to know about the latest in the sphere of research and knowledge. We have taken a small step and we hope that with the active co-operation of like-minded scholars, we shall be able to serve the society with our humble efforts.

Our Other Journals