S. EJAZ AHMED
University of Windsor

Panelized and Shrinkage Estimation in Partially Linear Models

Panelized and shrinkage regression have been widely used in high-dimensional data analysis. Much recent work has been done on the study of penalized least square methods in linear models. In this talk, we consider an absolute penalty type estimator (APE) for partially linear models, which is an extension of the Lasso method for linear models. We also consider Stein-type and pretest semiparametric estimators for this model with potential irrelevant presence of nuisance variables. We establish the asymptotic results for shrinkage and pretest estimators. A Monte Carlo comparison of the proposed estimators is presented. The comparison shows that the shrinkage method performs better than the APE when the dimension of the restricted space is large.

S. EJAZ AHMED AND MOHAMED AMEZZIAN
University of Windsor, DePaul University

Semiparametric Density Estimation

We explore the usefulness of shrinkage strategy as a means of constructing semi-parametric density estimators. We investigate the properties of the shrinkage coefficient and study the optimality and limiting distribution of the new density estimator. We also devise a related test of goodness-of-fit about the density. Theoretical results are supported by an extensive simulation study

MAYER ALVO
University of Ottawa

Nonparametric Tests of Hypotheses for Umbrella Alternatives

A general method is proposed for constructing nonparametric tests of hypotheses for umbrella alternatives. Such alternatives arise in situations where the treatment effect changes in direction after reaching a peak. Our class of tests are based on the ranks of the observations. The general approach consists of defining two sets of rankings: the first is induced by the alternative and the other by the data itself. The test statistic measures the distance between the two sets. The asymptotic distributions are determined for some special cases of distances under both the null and the alternative hypothesis when the location of the peak is known or unknown. A limited simulation study shows that the tests have good power.

AURORE DELAIGLE
University of Bristol

Prediction in Measurement Error Models

Predicting the value of a variable Y corresponding to a future value of an explanatory variable X, based on a sample of previously observed independent data pairs (X1,Y1),...,(Xn,Yn) distributed like (X,Y), is very important in statistics. In the error-free case, where X is observed accurately, this problem is strongly related to that of standard regression estimation, since prediction of Y can be achieved via estimation of the regression curve E(Y—X).

When the observed X-values and the future observation of X are measured with error, prediction is of a quite different nature. Here, if W denotes the future (contaminated) available version of X, prediction of Y can be achieved via estimation of E(Y—W). In practice, estimating E(Y—W) can be quite challenging, as data may be collected under different conditions, making the measurement errors on Xi and X non-identically distributed. We take up this problem in the nonparametric setting and introduce estimators which allow a highly adaptive approach to smoothing. Reflecting the complexity of the problem, optimal rates of convergence of estimators can vary from the semiparametric n-1/2 rate to much slower rates that are characteristic of nonparametric problems: the possibility of achieving parametric rates of convergence in nonparametric problems is very surprising. Nevertheless, we are able to develop highly adaptive, data-driven methods that achieve very good performance in practice. An empirical illustration from regression calibration in nutritional epidemiology illustrates the potential for great gains in efficiency using our methods.

(Joint work with Raymond Carroll and Peter Hall)

ABDUL GHAPOR HUSSIN
University of Malaya

The Complex Linear Functional Relationship Model and Detection of Outliers

Fitting a straight line when both variables are circular and subject to errors has not received any attention. What we mean by a circular variable is one which takes values on the circumference of a circle, i.e. they are angles in the range (0,) radians or (00, 3600). This variable must be analysed by techniques different from those appropriate for the usual Euclidean type variable because the circumference is a bounded closed space where the concept of origin is arbitrary or undefined. A continuous linear variable is a variable with realisations on the straight line which may be analysed straightforwardly with the usual techniques. This paper proposed an approach to fitting a straight line when both the variables are circular, subject to measurement and other errors by using the complex linear regression model, where the circular data can be expressed in the form of direction cosines or complex form, as an example, a circular observation is written in the form of . The model is called the complex linear functional relationship and linear refers to the fact that the relationship itself is linear but the variables involved are circular. By using the maximum likelihood estimation, the closed-form expression for the maximum likelihood estimators are not available and the estimates may be obtained iteratively by choosing a suitable initial value. This paper also extends the COVRATIO statistics which is originally used to identify outliers in linear regression to the complex linear functional relationship model. The model is illustrated with an application to the analysis of the wind direction data recorded by two different techniques: the HF radar system and the anchored wave buoy.

Subject Classification: 62H11

Keywords: circular variables; complex linear functional model; outlier.

S. EJAZ AHMED, ABDULKADIR HUSSEIN*, AND SEVERIEN NKURUNZIZA
University of Windsor

Robust Inference Strategy in the Presence of Measurements Error

In this talk, we consider to improve the performance of the maximum empirical likelihood estimator (MELE) established in the presence of measurement error. More precisely, we consider the case where the parameter vector is suspected to be subject to some constraints, and then we develop the inference method which combines both sample and non-sample information. More specifically, we suggest a shrinkage estimation strategy and develop the asymptotic properties. We also present simulation results on the finite sample efficiency of these estimators. We demonstrate that our proposed shrinkage estimator is superior to benchmark MELE both analytically and numerically.

JANA JURECKOVA
Charles University in Prague

Rank Tests in Partially Linear and Measurement Errors Models

Consider the partially linear regression model

$$Y_{ni} = \beta_0 + \mathbf{x}_{ni}^\top \beta + \nu(Z_{ni}) + e_{ni}, \quad i = 1, \dots, n \tag{1}$$

where $\mathbf{x}_{ni}$ is a p-vector covariate, Z_{ni} is a scalar covariate, the function $\nu(\cdot)$ is unknown, and the model error e_{ni} is independent of $(\mathbf{x}_{ni}, Z_{ni})$, $i = 1, \dots, n$. It means that the response variable Y_{ni} depends on variable $\mathbf{x}_{ni}$ in a linear way but is still related to another independent variables Z_{ni} in an unspecified form, $i = 1, \dots, n$. The independent errors

$e_{n1}, \ldots, e_{nn}$, are identically distributed according to an unknown distribution function F, and $\beta = (\beta_1, \ldots, \beta_p)^\top$, $\beta^* = (\beta_0, \beta^\top)^\top$ are unknown parameters.

Parallelly, consider the linear regression model

$$Y_{ni} = \beta_0 + \mathbf{x}_{ni}^\top \beta + e_{ni}, \quad i = 1, \ldots, n \tag{2}$$

in which the responses Y_{ni} can be only observed with additive measurement errors $V_{ni},\ i = 1, \ldots, n$, hence we can only observe $W_{ni} = Y_{ni} + V_{ni},\ i = 1, \ldots, n$.

Jureckova, Picek and Saleh (2008) considered the possibility of rank testing in model (2), in the situation that the covariates are measured with random errors, and showed that in some situations the usual rank tests can be still used and keep the size, while the measurement errors only affect their powers.

We shall consider models (1) and (2) in the situation that the responses $Y_{n1}, \ldots, Y_{nn}$ are affected by random errors. Our interest is to find how the rank tests of hypothesis $\mathbf{H}_0 :\ \beta = \mathbf{0}$ behave if we ignore either the covariates $Z_{n1}, \ldots, Z_{nn}$ or the measurement errors $V_{n1}, \ldots, V_{nn}$. If $Z_{n1}, \ldots, Z_{nn}$ or $V_{n1}, \ldots, V_{nn}$ are identically distributed, then the rank tests can keep their classical form, only their powers are affected.

The rank tests can be considered even in the case of non-identically distributed $Z_{n1}, \ldots, Z_{nn}$ or $V_{n1}, \ldots, V_{nn}$. Ignoring the measurement errors can change the size of the test, both finite sample and asymptotic. Some rank tests still have sizes close to α, if the distribution functions are close to each others. In case of one-dimensional β, the tests are unbiased with respect to one-sided alternatives $\beta > 0$. Generally are the tests consistent with respect to distant alternatives, but possibly with changed sizes. The situation is quite analogous in the partially linear models.

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JAN KALINA
Charles University in Prague

Locally Most Powerful Tests Based on Sequential Ranks

Sequential ranks of data $X_1, X_2, \ldots$ observed sequentially in time are defined as ranks computed from the data observed so far, denoting R_{ii} the rank of X_i among the values $X_1, X_2, \ldots, X_i$ for any i.

This paper studies tests of various hypotheses based on sequential ranks and derives such tests, which are locally most powerful among all tests based on sequential ranks. Such locally most powerful sequential rank test is derived for the hypothesis of randomness against a general alternative, including the two-sample difference in location or regression in location as special cases for the alternative hypothesis. Further, the locally most powerful sequential rank tests are derived for the one-sample problem and for independence of two samples. The proofs are analogous to the classical results of Hájek and Šidák (1967) for (classical) ranks.

The new tests are suitable for the situation when data are observed sequentially in time and the test is carried out each time after obtaining a new observation. While the classical rank tests require to recalculate all values of the ranks each time, the methods based on sequential ranks only require to compute the sequential rank of the only one new observation.

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HM KIM
University of Calgary

Bias in the Estimation of Exposure Effects with Group-Based Exposure Assessment

In epidemiological studies, an individual-based exposure assessment implies that an exposure estimate has been obtained for each person. In contrast, a group-based exposure assessment implies that all persons in a group are assigned a score. We analyses bias in estimates of exposure-disease associations that use group-based exposure assessments in conjunction with linear or logistic regression models. This approach allows fixed group effects in the exposure model. We introduce a quasi-Berkson error structure that can be justified when moderately large samples are drawn from each group. We also discuss other estimation methods when the sample size is small. Joint work with CG Park

HIRA L. KOUL
Michigan State University

Model Checking in Partial Linear Regression Models with Berkson Measurement Errors

This paper discusses the problem of fitting a parametric model to the nonparametric component in partially linear regression models when covariates in parametric and nonparametric parts are subject to Berkson measurement errors. Proposed test is based on the supremum of a martingale transform of a certain partial sum process of calibrated residuals. Asymptotic null distribution of this transformed process is shown to be the same as that of standard Brownian motion. Consistency of this sequence of tests at some

fixed alternatives and asymptotic power under some local nonparametric alternatives are also discussed. A simulation study is conducted to assess the finite sample performance of the proposed test. A Monte Carlo power comparison with some of the existing tests shows some superiority of the proposed test at the chosen alternatives. Joint work with Weixing Song, Kansas State University

RAFAL KULIK
University of Ottawa

Wavelet regression in random design with heteroscedastic dependent errors.

We investigate function estimation in nonparametric regression models with random design and heteroscedastic correlated noise. Adaptive properties of warped wavelet nonlinear approximations are studied over a wide range of Besov scales and for a variety of error measures. We consider error distributions with Long-Range-Dependence parameter $\alpha, 0 < \alpha \leq 1$, heteroscedasticity is modeled with a design dependent function σ. We give a moment condition on σ with respect to the design distribution and prescribe various tuning paradigms under which warped wavelet estimation achieves adaptivity results. For $p > 2$, it is seen that there are three rate phases, namely the dense, sparse and long range dependence phase, depending on the relative values of parameters. For smooth σ, we show that long range dependence does not come into play for shape estimation. The theory is illustrated with some numerical examples.

Based on joint work with Marc Raimondo.

BORIS LEVIT
Queen's University

Minimax revisited, or 'asymptopia' in the age of personal computers

Various non-asymptotic lower bounds in the minimax estimation of nor- mal means, due to Van Trees, Chentsov, Bhattacharyya, Kooks, Donoho, and others, will be reviewed and compared. These results will be then applied to non-parametric estimation in the White Gaussian noise, for various nonparametric functional classes. An o- hand asymptotic approach to optimal estimation is shown to be unreliable and, at times, misleading. Questions about comparing dierent functional classes and the role of adaptation will be discussed. In this regards, some useful insights can be gained through the use of computers, as will be demonstrated.

YANYUAN MA
Texas A and M

Score-Type Tests in Semiparametric Measurement Error Models, with Applications to Testing Lack of Fit

We propose and study score-like tests in the context of measurement error models. We consider functional measurement error models, i.e., measurement error models where no distributional assumptions are made about the variable measured with error. In the functional measurement error context, where no likelihood function is available or calculated, our tests have optimality properties and computational advantages similar to those of the classical score tests. The test procedures are applicable to several semiparametric extensions of measurement error models, including when the measurement error distribution is estimated nonparametrically as well as for generalized partially linear models. We also study lack-of-fit issues and propose a feasible omnibus testing procedure. The performance of the local and omnibus tests is demonstrated through simulation studies and analysis of a nutrition data set.

YULIYA V. MARTSYNYUK
Carleton University

Invariance Principles and Functional Asymptotic Confidence Intervals for the Slope in Linear Structural and Functional Error-in-Variables Models

A modified least squares process (MLSP) is introduced in $D[0,1]$ for the slope in linear structural and functional error-in-variables models (EIVM's). Sup-norm approximations in probability and, as a consequence, functional central limit theorems (FCLT's) are established for a data-based self-normalized version of this MLSP. MLSP is believed to be a new type of object of study, and invariance principles for it constitute new asymptotics, in EIVM's. Moreover, the obtained data-based FCLT's for the MLSP open up new possibilities for constructing various asymptotic confidence intervals (CI's) for the slope that we call functional asymptotic CI's. Two special examples of such CI's are given. The talk highlights some of the speakers selected publications.

IVAN MIZERA
University of Alberta

Density Estimation via Penalized Maximum Entropy

Penalized maximum likelihood method for density estimation, if considered as a convex optimization problem, has an equivalent formulation via its conjugate dual, the formulation that can be interpreted as a kind of maximum entropy prescription. This fact can be explored in several aspects and directions. By considering a broader class of Renyi's entropies, it is possible to obtained old and new formulations beyond maximum likelihood; their properties can be then explored within the classes of shape-constrained, as well as unconstrained, penalized density estimators.

This time, we focus on the shape-unconstrained, penalized case. It seems that from the mathematical (the duality relation mentioned above was so far rigorously established only for discrete approximations), but perhaps also from the conceptual point of view, it is good to proceed not from the primal to the dual, but in the opposite direction: that is, to start with penalized maximum entropy density formulation. Our general setting encompasses different orders of differentiation in the penalty, as well as various styles of L2 and L1 penalization - the latter with connections with the so-called tube methods. Before turning to duals, that is, to equivalent maximum likelihood formulations, we explore different aspects of the maximum entropy primal, like limiting form of the estimators when relaxing the penalization tuning parameter. Of particular interest are the possible consequences for the behavior of the estimation methods with growing dimension of the sample space.

JAN PICEK
Technical University of Liberec

Rank scores tests in measurement error models - computational aspects

Consider the linear regression model

$$Y_i = \beta_0 + \mathbf{x}'_{ni}\beta + \mathbf{z}'_{ni}\delta + e_i, \quad i = 1, \ldots, n \tag{3}$$

with observations $Y_1, \ldots, Y_n$, independent errors $e_1, \ldots, e_n$, identically distributed according to an unknown distribution function F; $\mathbf{x}_{ni} = (x_{i1}, \ldots, x_{ip})'$, $\mathbf{z}_{ni} = (z_{i1}, \ldots, z_{iq})'$ are the rows of regression matrices, β_0, $\beta \in \mathbb{R}^p$, $\delta \in \mathbb{R}^q$, are unknown parameters.

We want to test the hypothesis

$$\mathbf{H}: \ \delta = \mathbf{0}, \tag{4}$$

considering β_0 and β as a nuisance parameters.

In the model without measurement errors, the hypothesis (4) can be tested by the regression rank score test. If the regressors are affected by random measurement errors then Jurečková, Picek and Saleh (2008) considered the tests based on the regression rank scores. No estimation of the nuisance parameters is necessary. If the $\mathbf{x}_{ni}$ or both the $\mathbf{x}_{ni}$ and $\mathbf{z}_{ni}$ are affected by random errors then we cannot use a regression rank scores test. Jurečková, Picek and Saleh (2008) suggested the aligned rank test with estimated nuisance parameters.

The present paper deals with the computational aspects of both test procedures. The efficiency changes caused by the measurement errors is also illustrated by a simulation study.

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J. N. K. RAO
Carleton University

*Small Area Estimation under Nested Error Regression Models with Measurement Errors in the Covariates**

Small area estimation has been extensively studied under nested error linear regression models, assuming no measurement errors in the covariates. Empirical Bayes (EB) estimators of small area means that borrow strength across areas through the linking model and nearly unbiased estimators of mean squared prediction error (MSPE) of the EB estimators have been proposed in the literature. In this talk I will study EB estimation under both structural and functional measurement error models. Fully efficient EB estimators that make use of all the available data for the structural case are obtained and shown to be considerably more efficient than some recently proposed estimators. A nearly unbiased jackknife estimator of MSPE is also proposed. In the functional case, fully efficient pseudo-EB estimators are derived and their MSPE is estimated through a parametric

bootstrap method. Simulation results on the performance of the proposed methods will also be reported. * Joint work with Gauri Datta, University of Georgia and Mahmoud Torabi, University of Alberta.

PRANAB K. SEN
University of North Carolina at Chapel Hill

The Theil-Sen Estimator in a Measurement Error Perspective

For a simple regression model ($Y = \theta + \beta x + e$), the estimator of the slope parameter (β) based on the Kendall tau statistic, known as the Theil-Sen estimator (TSE), is robust and provides a distribution-free confidence interval. It has other desirable properties too (Sen 1968, JASA). When the regressors (X) are themselves stochastic and are subject to measurement errors, like the classical least squares estimator (LSE), the TSE does not estimate the slope β unbiasedly or even consistently. If the observable regressors ($W = X + V$) have the variance σ_w^2 and the unobervable X has the variance σ_x^2, then the LSE estimates the adjusted regression parameter $\gamma = \rho\beta$ where $\rho = \sigma_x^2/\sigma_w^2$. There is a basic qualm: What does the TSE estimate in a measurement error model and when does it estimate γ?

Researchers in the past have heavily relied on normal distributional assumptions on the errors e, V as well as W, albeit in practice none of these error components are likely to be normally distributed. It can be shown that even without the normality assumption, the LSE may converge in probability (or almost surely) to γ, albeit it may not be an unbiased estimator for nonnormal error distributions, thus compromising its finite sample optimal or desirable properties. The situation with the TSE is more complex and involved. It is shown that even if the normality assumptions on the error components are dispensed with, under quite general regularity assumptions, the TSE is a median-unbiased estimator of γ and it shares some other desirable properties, known to be tenable in a simple regression model. The distribution-freeness of the confidence interval for γ (or β) based on the TSE (Sen 1968) may, however, be untenable for measurement error models, in general.

With these characterisations, the use of LSE and TSE in simple measurement error models will be elaborated in a separate communication.

SANJOY K. SINHA
Carleton University

Robust analysis of generalized linear mixed models with missing responses

The EM algorithm is a commonly used iterative method for analyzing incomplete data with generalized linear mixed models. The maximum likelihood estimators obtained from the EM method are generally sensitive to outliers or departures from the underlying assumptions. In this talk, I will discuss a robust method for analyzing dependent data with missing responses. The robust method is developed in the framework of the maximum likelihood, and is useful for downweighting any influential points in the observed data when estimating the model parameters. Simulations were carried out to study the behaviour of the proposed robust method in the presence of outliers. I will discuss the results from the simulation study. I will also discuss some aspects of robust estimation in measurement error models.

KEY WORDS: Generalized linear model; measurement error; missing response; mixed model; robust estimation.

WEIXING SONG
Kansas State University

Improved Estimation in Multiple Linear Regression Models with Measurement Error and General Constraint

Two restricted estimators for the regression parameters in a multiple linear regression model with measurement errors are constructed when prior information for the parameters is available. We then construct two sets of improved estimators which include the preliminary test estimator, the stein-type estimator and the positive rule stein type estimator, are constructed for both slopes and intercept, and examine their statistic properties such as the asymptotic distributional quadratic biases, the asymptotic distributional quadratic risks. We remove the distribution assumption on the error term, which was generally imposed in literature, but provide a more general investigation of comparison of the quadratic risks for these estimators. Simulation studies illustrate the finite-sample performance of the proposed estimators. The proposed estimators are finally used to analyze a dataset from the Nurses Health Study.

JOHN STAUDENMAYER
University of Massachusetts

Density estimation in the presence of heteroskedastic measurement error

We consider density estimation when the variable of interest is subject to heteroskedastic measurement error. The density is assumed to have a smooth but unknown functional form which we model with a penalized mixture of B-splines. We treat the situation where multiple mismeasured observations of each of the variables of interest are observed for at least some of the subjects, and the measurement error is assumed to be additive and normal. The measurement error variance function is modeled with a second penalized mixture of B-splines. The paper's main contributions are to address the effects of heteroskedastic measurement error, to explain the biases caused by ignoring heteroskedasticity, and to present an approximate equivalent kernel for a spline based density estimator. The derivation of the equivalent kernel may be of independent interest. We use small-sigma asymptotics to approximate the biases incurred by assuming the measurement error is homoskedastic when it actually is heteroskedastic. The biases incurred by misspecifying heteroskedastic measurement error as homoskedastic can be substantial. We fit the model using Bayesian methods. An example from nutritional epidemiology and an example that uses simulated data are included. This is joint work with David Ruppert and John Buonaccorsi.

NATALIA STEPANOVA AND YURI INGSTER

Carleton University and St.Petersburg State Electrotechnical University

On Estimation and Detection of Multivariate Functions

In nonparametric statistics, the problems of estimating and detecting an unknown signal f observed with white noise are of great importance and interest. Compared to a univariate case, efficient methods of estimation and detection of multivariate functions are known to behave poorly. A similar phenomenon appears in many mathematical settings related to multivariate functions and is often referred to as the "curse of dimensionality". One way to avoid it is to assume that the signal f belongs to a certain weighted tensor product space. The idea behind such a space is to reduce the "working dimension" of the problem. Informally, it is assumed that: (i) f can be approximated by the sum of a small number of functions of a small number of variables, and (ii) the variables are ordered according to their importance. The "weighted approach" to the problem of estimating and detecting multivariate functions was recently developed for classes of functions of finite smoothness by Ingster and Suslina (2007). In this talk we consider the case of analytic functions.

One problem of our interest is to estimate an unknown multivariate signal f using quadratic loss. Another problem of interest is to detect f, that is, to test the hypothesis

$H_0 : f = 0$ versus nonparametric alternatives of the form $H_{1\varepsilon} : \|f\|_2 \geq r_\varepsilon$, where $\|\cdot\|_2$ is the L_2-norm, $\varepsilon > 0$ is a small parameter (noise intensity), and $r_\varepsilon \to 0$ is a positive family. Within the framework of the minimax approach, these two problems are closely related to each other.

In connection with estimating and detecting unknown signal, the problems of rate and sharp optimality are investigated. The results obtained illustrate the advantage of using tensor product spaces in multivariate settings: for such spaces the curse of dimensionality effect can be avoided.

LIQUN WANG
University of Manitoba

Identifiability and estimation of nonlinear semiparametric models with measurement errors

In this talk I will propose moments- and simulation-based based estimators for a nonlinear errors-in-variables model where the distributions of the unobserved predictor variables and of the measurement errors are nonparametric. These estimators are root-n consistent and computaionally always feasible. I will also present root-n consistent semiparametric estimators and a rank condition for model identifiability based on the combined methods of nonparametric technique and Fourier deconvolution. Monte Carlo simulaiton studies will be presented to illustrate these methods.

SILVELYN ZWANZIG
Uppsala University

On R-estimation in errors-in-variables models

Consider a simple linear errors-in-variables model

$$y_i = \beta\xi_i + \varepsilon_i,\ x_i = \xi_i + \delta_i,\ i = 1, .., n$$

with *i.i.d.* errors. The naive R-estimator is defined by

$$\widehat{\beta}_{naive,R} = \arg\min_{\beta} D_{naive}\left(\beta\right),\ D_{naive}(\beta) = \sum_{i=1}^{n}(y_i - x_i\beta)a_n(R(y_i - x_i\beta))$$

where $D_{naive}(\beta)$ is Jaeckels dispersion in the model $y_i = \beta x_i + \varepsilon_i$, $R(y_i - x_i\beta)$ denotes the rank of $y_i - x_i\beta$, the scores $a_n(i)$ are generated by a score function φ. Using results of Kuljus and Zwanzig (2008) the asymptotic behavior of $\widehat{\beta}_{naive,R}$ is studied for $n \to \infty$. A bias correction with SIMEX will be discussed. A rank estimate which fits more

the errors-in-variables model can defined by using the orthogonal distance $d^2(y,x) = \min_\xi \left(|y-\beta\xi|^2 + |x-\xi|^2\right)$

$$\widehat{\beta}_{orth,R} = \arg\min_\beta D_{orth}\left(\beta\right), \quad D_{orth}(\beta) = \sum_{i=1}^{n} sign(i)\; d(y_i,x_i)\; a_n(R_i),$$

where R_i is the rank of $sign(i)\; d(y_i,x_i)$ with $sign(i)$ is 1 iff $(\dot{y}_i,x_i)$ lies over the line βx otherwise $sign(i)$ is -1.