

Quantile regression and forecast for reference growth charts

La regressione quantilica e la previsione nelle curve di crescita

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Riassunto: Le tecniche classicamente utilizzate per la stima delle curve di crescita pediatriche, ampiamente usate per individuare problemi di crescita nella primissima infanzia, prevedono delle ipotesi di normalità dei dati, caratterizzazione difficilmente ottenibile nel caso di misure antropometriche. In questo lavoro studieremo l'applicabilità e l'uso dei metodi di regressione quantilica non parametrica per la creazione di curve di crescita pediatriche utilizzando i dati attualmente disponibili e che riguardano i bambini italiani.

Keywords: Non parametric quantile regression, reference growth charts

1. Introduction

Reference growth charts are probably one of the most used tool by pediatricians in order to evaluate a healthy and regular growth of their young patients. At the end of the 19th century, we already find the first studies on this topic conceived by Quetelet (Quetelet (1871)). The methodology commonly used to create and estimate the reference growth charts are based on normality assumptions for the data and on specific transformation applied to age. For example, on April 27, 2006, the World Health Organization (WHO) published the new growth standards, completing a study started in 1997, after that in 1994 the review of WHO concluded that the *National Centre for Health Statistics (NCHS)* of 1977 did not adequately represent early childhood growth. Such standards are estimated on an effective sample of 1737 children (894 boys and 843 girls) from a diverse set of countries (USA, Oman, Norway, Brazil, Ghana and India). The children of the sample were screened and enrolled at birth and a total of 21 times on weeks 1, 2, 4 and 6, monthly from 2-12 months and bimonthly in the second year, in such a way to obtain 19900 total number of longitudinal data. The WHO's study selected as curve estimation distribution the Box-Cox-Power-Exponential (BCPE) with curve smoothing by cubic splines. Furthermore they used a power transformation of age because of the particular estimation procedure, see WHO Multicentre Growth Reference Study Group (2006).

Even if very complex, the method used by WHO is based on a transformation both of data and age, in order to assure the data normality assumption.

An approach based on quantile regression, as presented in Wei *et al.* (2006), allows a more flexible strategy. In that work, quantile regression is used to estimate both unconditional

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and conditional growth curves. In particular, *unconditional growth curves* depend solely on patient age: as for each i th child, with $i = 1, 2, \dots, n$, there are several measurements at different times, $\{Y_i(t_j) : j = 1, 2, \dots, J_i\}$; for such curves the longitudinal feature of the data is ignored and the sample is treated as made of independent realizations of different children. The method used to estimation is a quantile regression with a linear B-splines smoothing parameter. On the contrary, the conditional growth curves depend on age and on other covariates offering additional informations: in such a context, the quantile regression is a very flexible approach. In fact, we can evaluate even irregular structure in time series. In this case, given a sample of n children, the measurements, $\{Y_i(t_{i,j}) : j = 1, \dots, T_i, i = 1, \dots, n\}$, are not observed at equally spaced time intervals. To address these difficulties in Wei *et al.* (2006) a simple first order autoregression model is adopted where the AR(1) parameter is specified by a linear function of the time gap between two successive measurements. The τ th conditional quantile function is decomposed into three components: a non parametric trend, an AR(1) component and a partially linear component in the covariates (i.e. the average parental height).

The goal of our work is the transformation and the application of the techniques in Wei *et al.* (2006) to some data regarding italian children. The dataset we use, gently provided by Pedianet project (an organization to obtain epidemiological information, see www.pedianet.it), picks up the italian auxological measurements (length, weight and head circumference) of children from 2000. Such observations are made by about 300 pediatricians, distributed in Italy, supporting the scientific project and using a specific software property of So.Se.Pe srl. It's important to note that until now the reference growth charts based on italian children do not exist.

The modifications proposed for the techniques regards both the unconditional and the conditional growth curves. For the first ones we will estimate the curves in two ways: considering the original data, also if the measurements were not taken at equally spaced intervals, we use the quantile regression method with nonparametric functions; on estimated data, in order to obtain equally spaced time intervals, with two procedures: assuming a linear constant increase between two successive observations or by a parametric function based on estimated growth curves features.

For the conditional growth curves we will choose the best trend function and the autoregressive process and we will enclose different covariates such as the birth weight, sex, ethnic group and cohorts.

Furthermore, in order to obtain a diagnostic index, we propose a tool to describe the capability of the estimation procedure to explain the real quantile structure of the data.

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