POLITECNICO
MILANO 1863

Analyzing Italian fertility trends

Exploring the causes of Italy's newborns plunge

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The team

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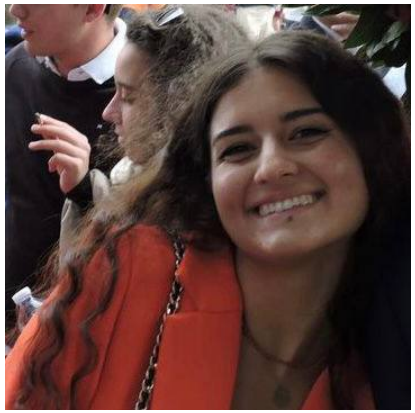

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The problem

- Problem: Italy's newborn plunge
- Why and how are the fertility rates decreasing?
- Dataset : Rates per year, province, age
- Why nonparametric?
  $\rightarrow$ Functional data

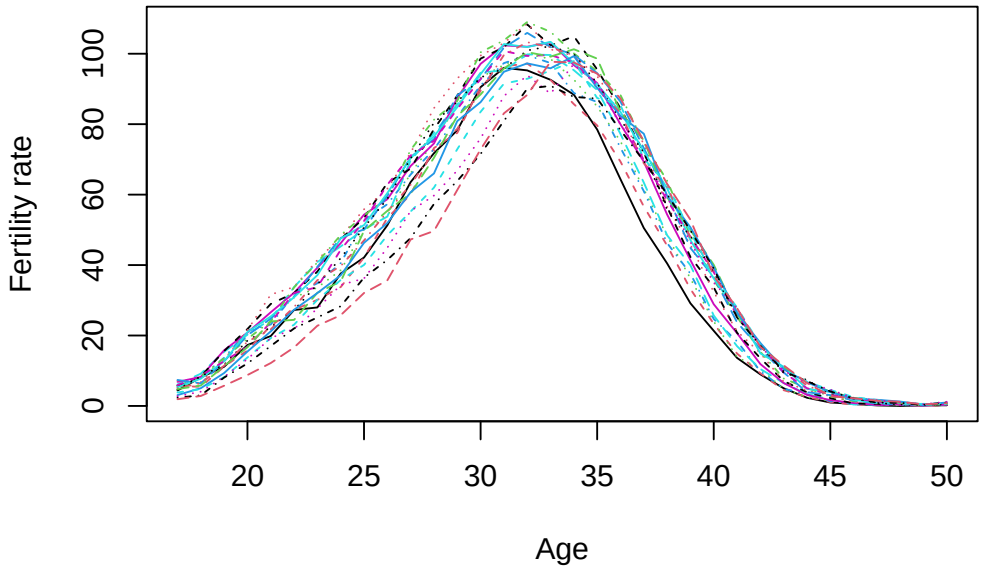
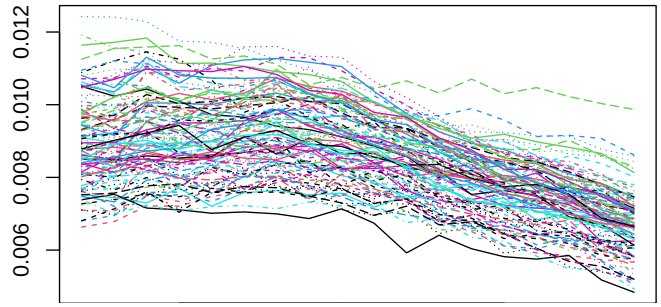


Figure: Newborns for 1000 women in Milano province, 2002-2019

Total newborns 2002-2021



For every year we test:

$$H_0 : X_{north} \stackrel{d}{=} X_{center} \stackrel{d}{=} X_{south}$$

$$H_1 : H_0^C \qquad T_0 = F$$

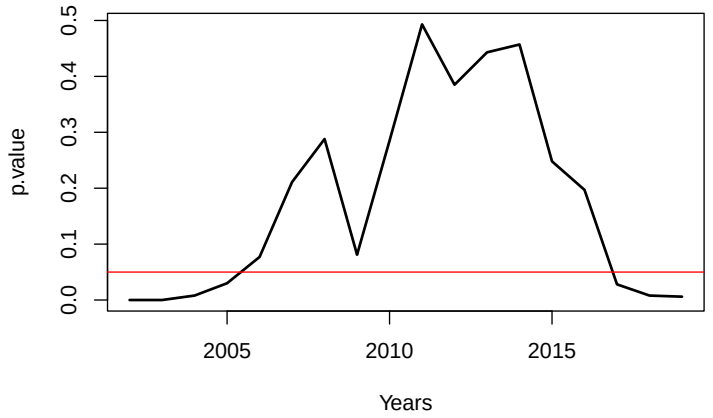


Figure: p-value along years, red line represent the threshold $\alpha = 0.05$

FDA approach: $f_{ij} : \mathbb{R} \to \mathbb{R}$

$$i = 2002, \ldots, 2021$$
$$j = \textit{Agrigento}, \ldots, \textit{Viterbo}$$

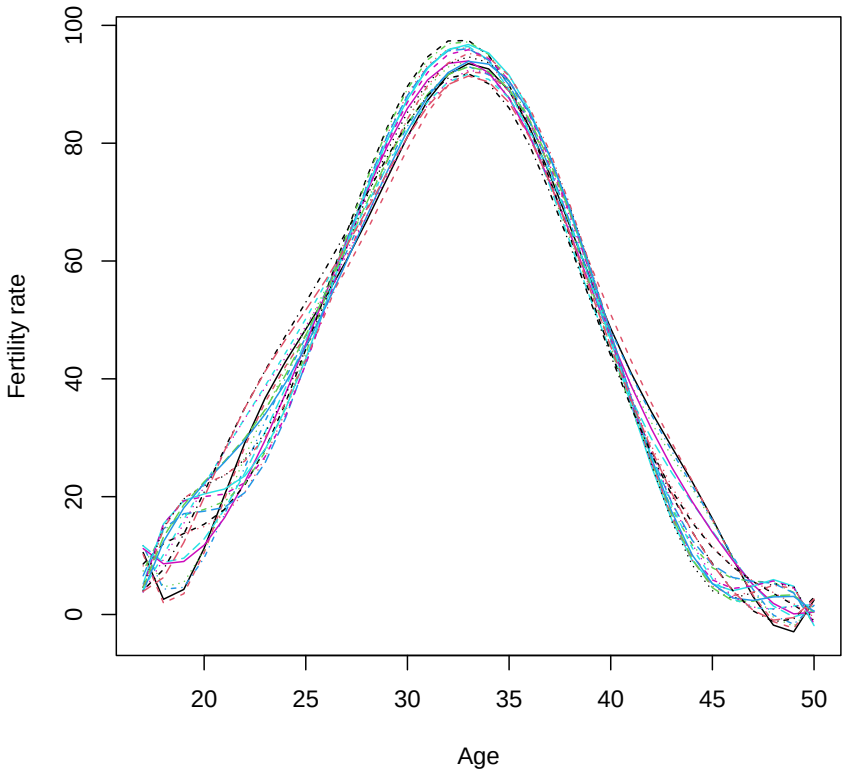
Projection measurements:

$$n_{ijk} = f_{ij}(k) + \epsilon_{ijk} \qquad k = 17, \ldots, 50$$

Inference on the second derivative $\Longrightarrow \{f_{ij}\} \in C^5_{[17,50]}$

$$\mathcal{P}(\lambda) = \int_{17}^{50} \left(f_{ij}^{(iv)}\right)^2 \quad \Longrightarrow \quad \text{Natural splines of order 5}$$

A focus on ages and years



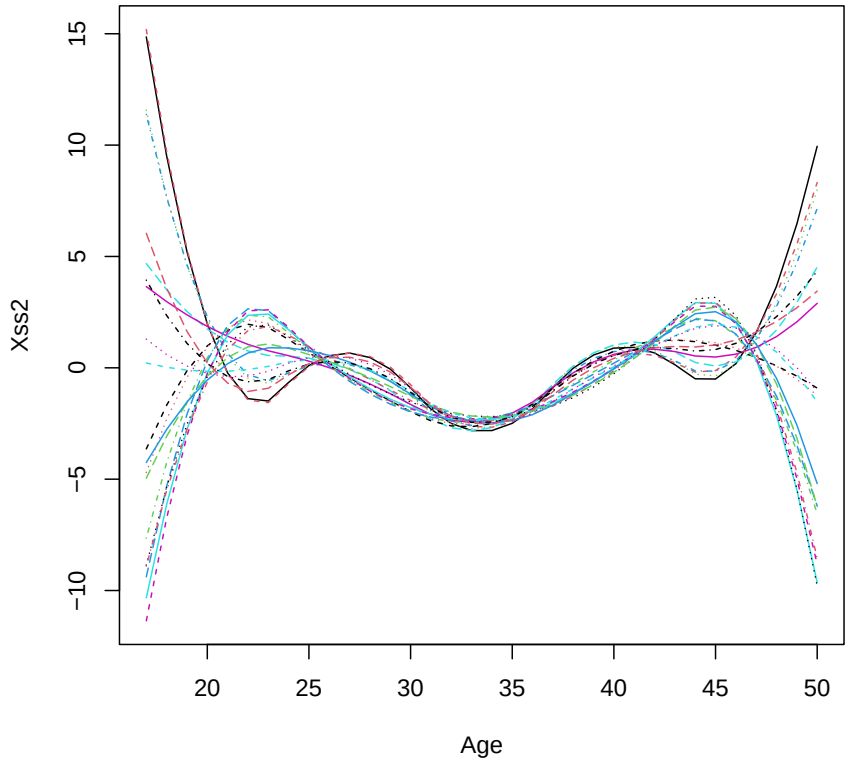
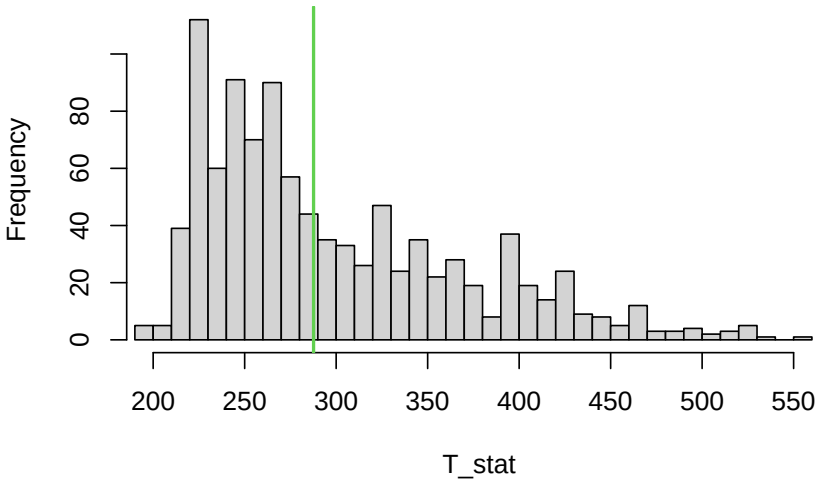


Figure: Smoothed fertility rates and their second derivatives, respectively

A focus on ages and provinces

$$H_0 : Med_{north} = Med_{center} = Med_{south} \quad H_1 : H_0^C$$

$$T_{stat} = \sum_{cyc} \left\| Med_i - Med_j \right\|_{L^1}$$



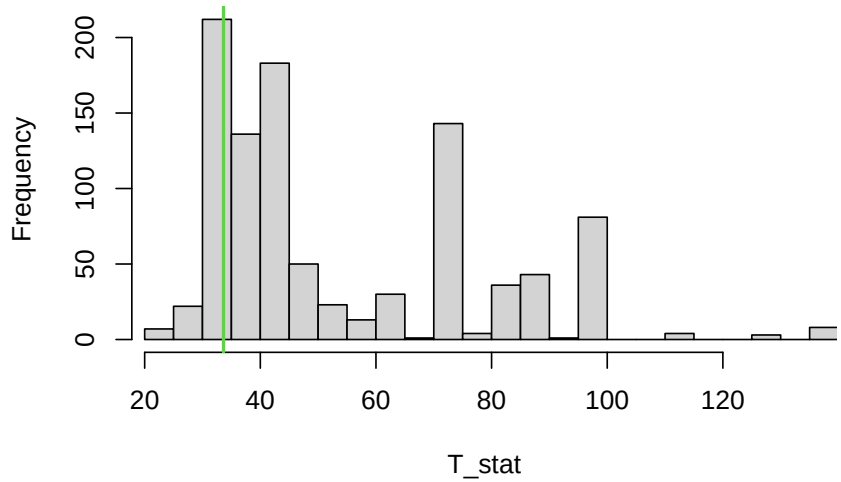


Figure: Permutation test on rates and their derivatives

Future Developments

- Nonparametric inference: Explore the variability in the spatio-temporal domain
- Find the best covariates to describe this variability through a semiparametric regression
- Predict the future fertility rates through conformal prediction

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