



**POLITECNICO**  
MILANO 1863



**Istat**

Istituto Nazionale  
di Statistica

## Analyzing Italian fertility trends

Exploring the causes of Italy's newborns plunge

**Mancinelli, Marchesin, Sisti, Venanzi**

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# The team

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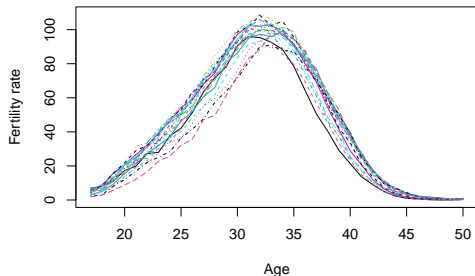


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- Problem: Italy's newborn plunge
- Why and how are the fertility rates decreasing?
- Dataset : Rates per year, province, age
- Why nonparametric?  
→ Functional data

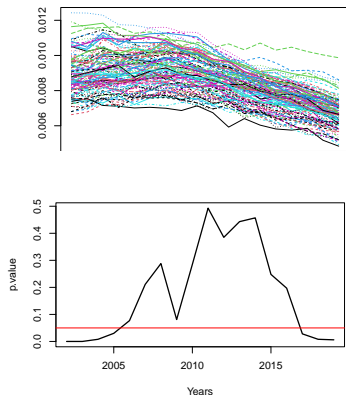


**Figure:** Newborns for 1000 women in Milano province, 2002-2019

For every year we test:

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

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



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

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

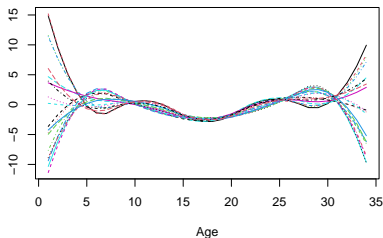
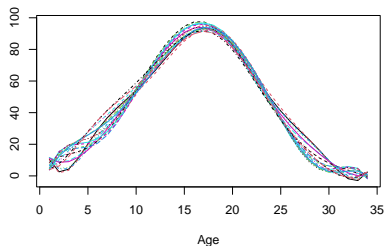
$$\begin{aligned} i &= 2002, \dots, 2021 \\ j &= \textit{Agrigento}, \dots, \textit{Viterbo} \end{aligned}$$

Projection measurements:

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

Inference on the second derivative  $\implies \{f_{ij}\} \in C_{[17,50]}^5$

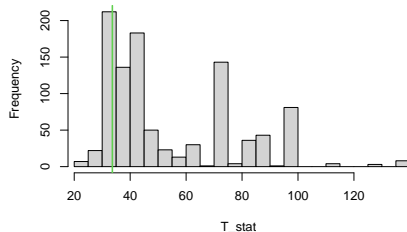
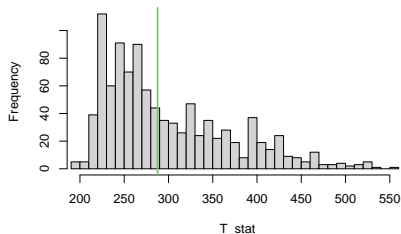
$$\mathcal{P}(\lambda) = \int_{17}^{50} (f_{ij}^{(iv)})^2 \implies \text{Natural splines of order 5}$$



**Figure:** Smoothed fertility rates and their second derivatives, respectively

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

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



**Figure:** Permutation test on rates and their derivatives

- 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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