Statistical Physics for Social Sciences

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ENSAE

Introduction : **From durable goods markets to fashion first names**

- The topic ?
  - Mathematical models are currently used to forecast sales of innovative goods. Inspired by the theory of diffusion processes developed for marketing economics, The paper propose a modelling framework for the mechanism of fashion, which we apply to first names.
- Is it important ? Game changer ?
  - Understanding how individuals make choices and how their choices interplay is a fundamental problem.
- Why do we choose this study ?
  - We were curious about a new explanation of our first names. It seems that there are other causes than the right sound or whatever. Despite the anxiety and the sometimes long search for the right name, there is a real fashion for first names.

Contents

I) The study

- **Research Article** : The Diffusion Dynamics of Choice : From Durable Goods Markets to Fashion First Names (accepted 3 December 2015)
- **Searchers** : BAPTISTE COULMONT,VIRGINIE SUPERVIE AND ROMULUS BREBAN
- **Database** : Dutch, USA and French
- **The aim of the study** :
  - The Market uses mathematical models based on the theory of diffusion to predict the spread of innovative and durable goods in the society
  - The theory of Diffusion tries to understand individuals choices interplay, **Diffusion Dynamics of Choice can be applied to Fashion First Names**
  - The Macroscopic/Microscopic Approach explains the dynamic and gives prediction
- Other studies have weaknesses: no dynamic and Fashion $\neq$ Popularity

I) Macroscopic Model

- Analogy between the dynamics of names and The Fashion spread of durable goods
- **Bass Model** (Developed for the sales of durable goods)

$$\frac{\mathrm{d}N}{\mathrm{d}t} = [p + q(\frac{N}{K})](K - N)$$

- **Variables** :
  - N : The number of sales
  - K : The Market size
  - p : The innovative coefficient related to the media coverage
  - q : The imitation coefficient
  - t : Time

I) Macroscopic Model in the case of first names

- Names don't have a media coverage $\Rightarrow p = 0$
- The Bass model gives :

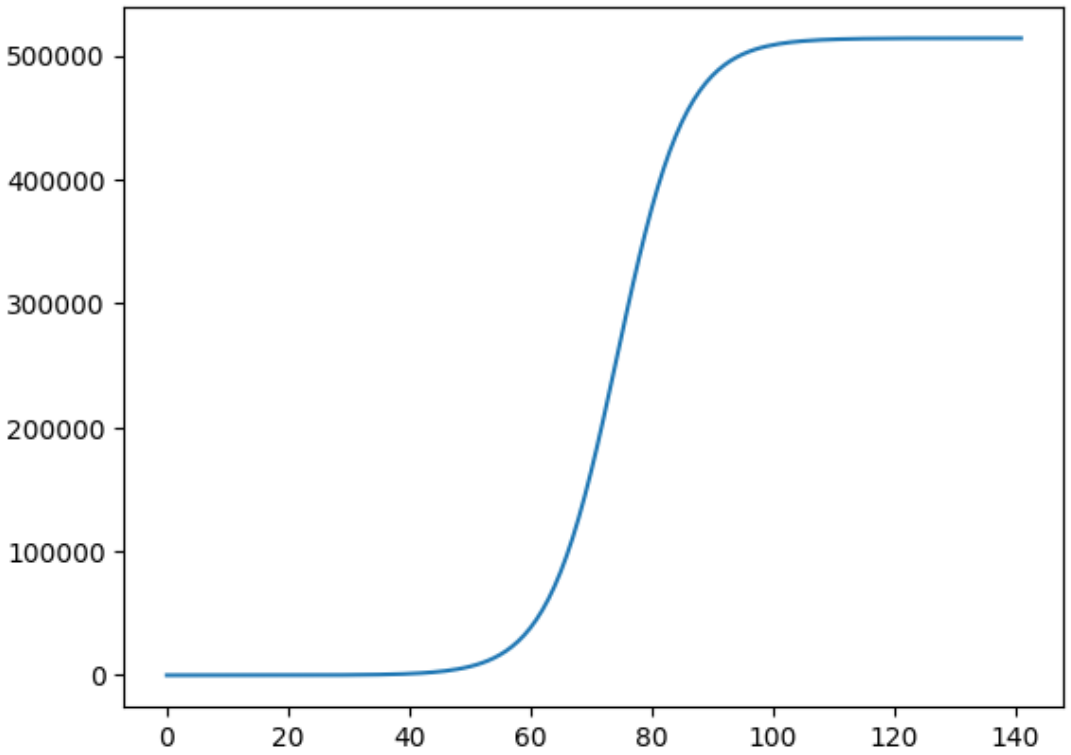
$$\frac{\mathrm{d}\eta}{\mathrm{d}t} = q\eta(1-\eta), \text{ with } \eta = \frac{N}{K}$$

- η is the fraction of adopters at time t
- K becomes the number of agents susceptible to adopt
- The number of adopters at time t : $K \cdot \eta(t)$
- The number of new adopters : $K \cdot \frac{\mathrm{d}\eta}{\mathrm{d}t}$ (What we have to plot)

I) Macroscopic Model : The S-function

- The solution of the differential equation is :

$$\eta(t) = \frac{1}{1+\frac{1-\eta_0}{\eta_0}.\mathrm{e}^{-qt}} \text{ with } \eta_0 \in]0,1[\text{ and } q > 0$$



The plot of $K \cdot \eta$

I) Macroscopic Model : Hypothesis

- Homogeneous society :
  - Constant population size P
  - Where the birth rate matches the death rate
  - Neglect death of the fashion name recipients before the fashion wave has passed
  - Each individual makes one name choice per lifetime
  - The individual communicates at time t with others and cumulates positive and negative advice adopting the fashion name

I) Microscopic Model : Game of social interactions

- The game provides the pay-off of social interactions of individuals following two strategies :
  - either 1 : having chosen a particular fashion name
  - or 2 : having chosen any other name or being undecided

I) Microscopic Model with Game Theory

- Matrix of Pay-off : Fashion X Other Names

$$\begin{bmatrix} (-\gamma,-\gamma) & (\alpha,-\beta) \\ (-\beta,\alpha) & (0,0) \end{bmatrix} \text{ with } \alpha,\ \beta \text{ and } \gamma > 0$$

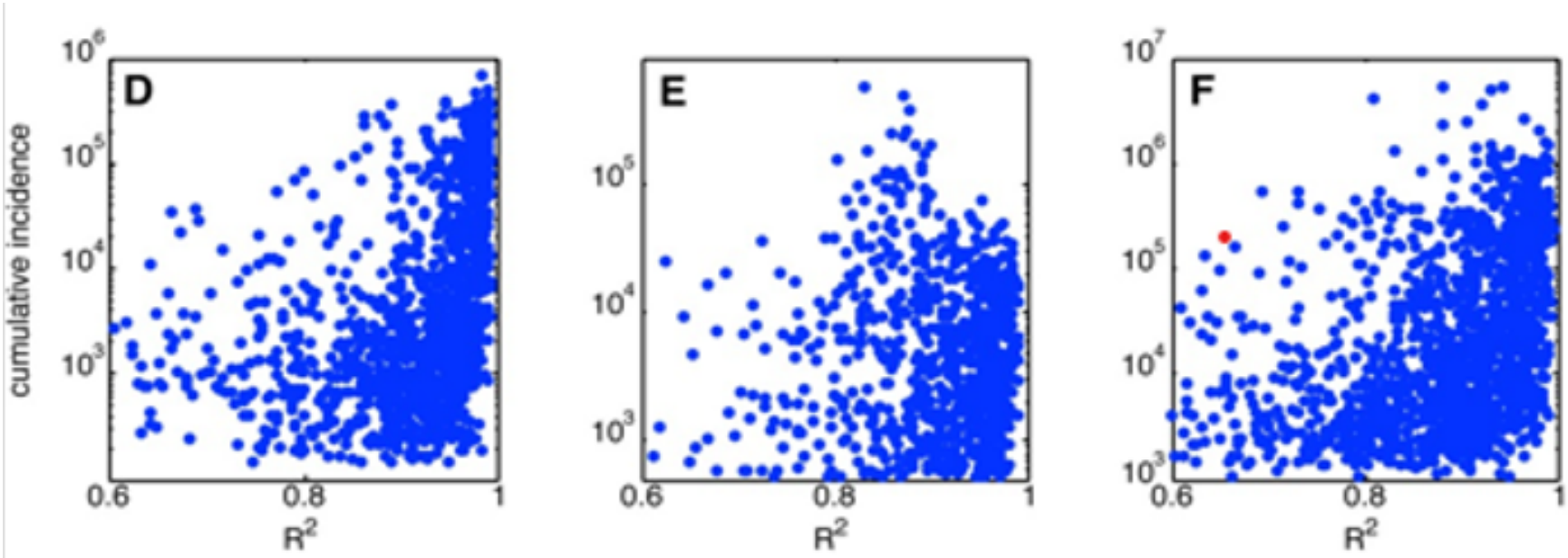
  - Let P representing the Population:

$$\Pi_{fashion} = K\eta(t)[\alpha(P - K\eta(t)) - \gamma K\eta(t)]$$
$$\Pi_{other} = (P - K\eta(t))(0 - \beta K\eta(t))$$

$$\boxed{K \cdot \frac{\mathrm{d}\eta}{\mathrm{d}t} \propto \frac{\Pi_{fashion} - \Pi_{other}}{P}} \Rightarrow \textit{Logistic equation}$$

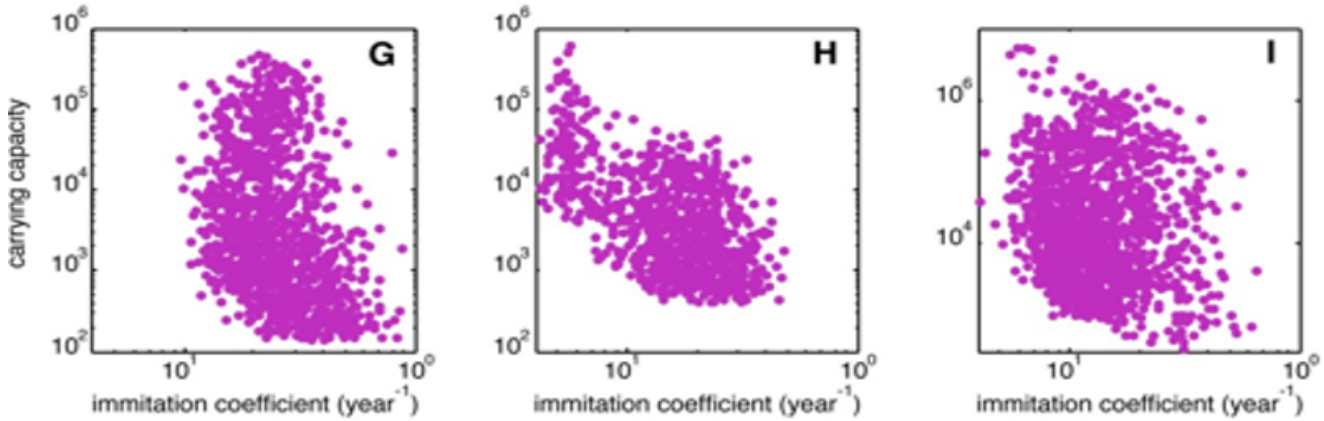
I) Results of The Study : the reliability of the study

- The R^2 around the peak of incidence is larger than 0.6
- The fit used is a nonlinear least-square fitting
- **Results:**

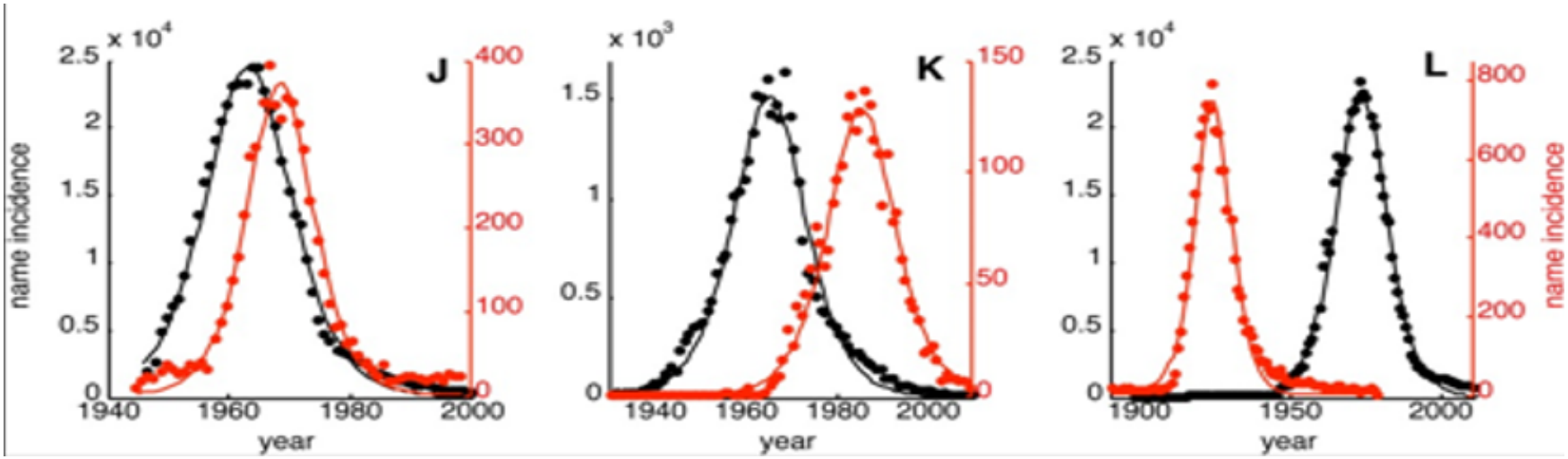


I) Results of The Study

- Dynamics : several possible fashion profiles:

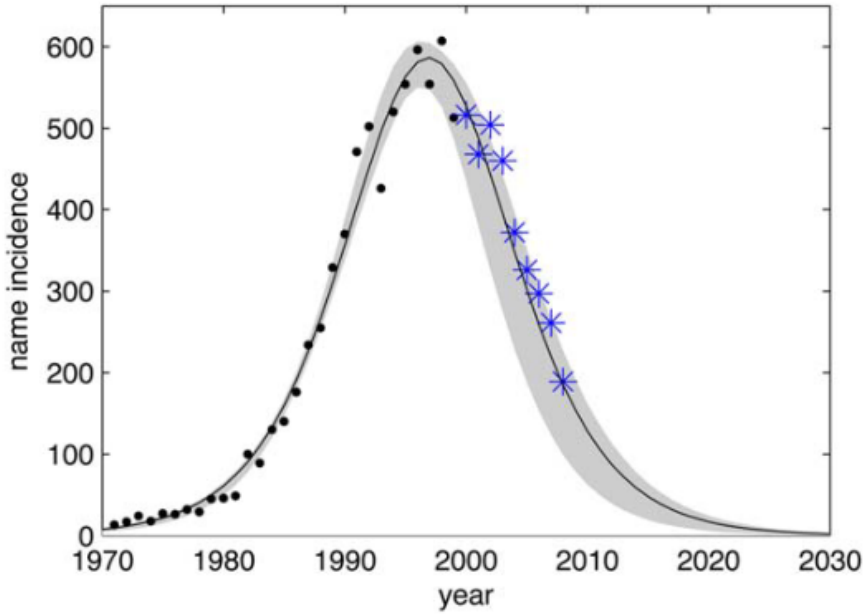


- Prediction : low and high popularity



I) Results of the Study : The French case of Floriane and some critics.

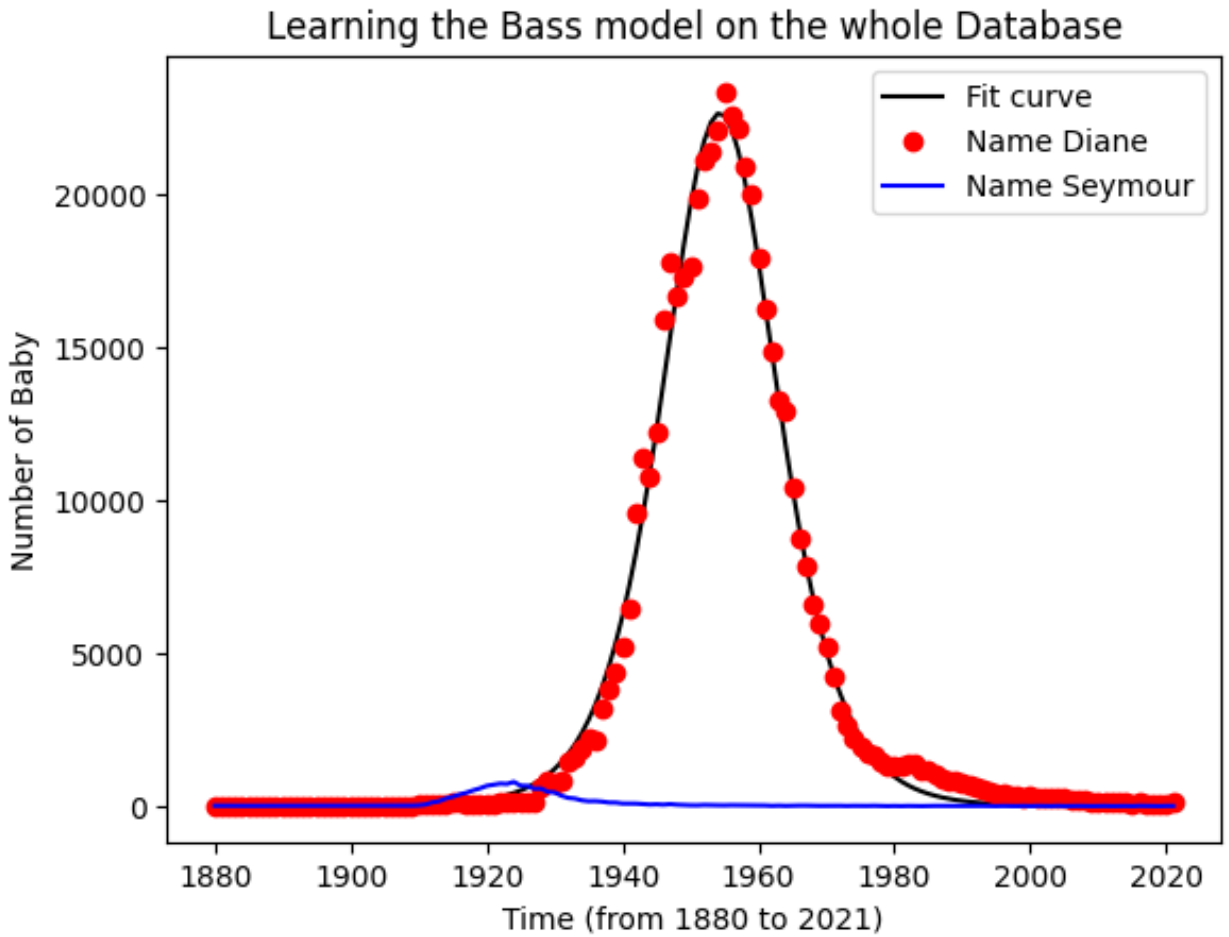
- Prediction : The incidence of Floriane between 2000 and 2008.



- Critics or limits :
  - The class structutre and social distinction
  - Internal process
  - Not apply to names that are transmitted from parents to children.

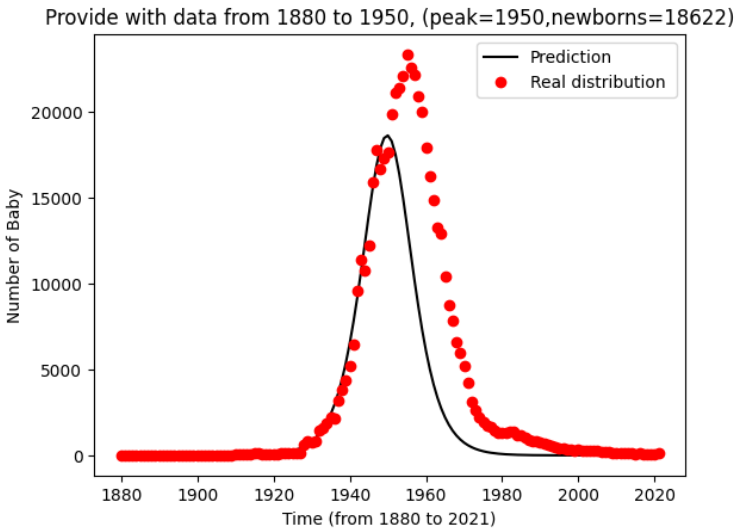
II) Bass Model for first names

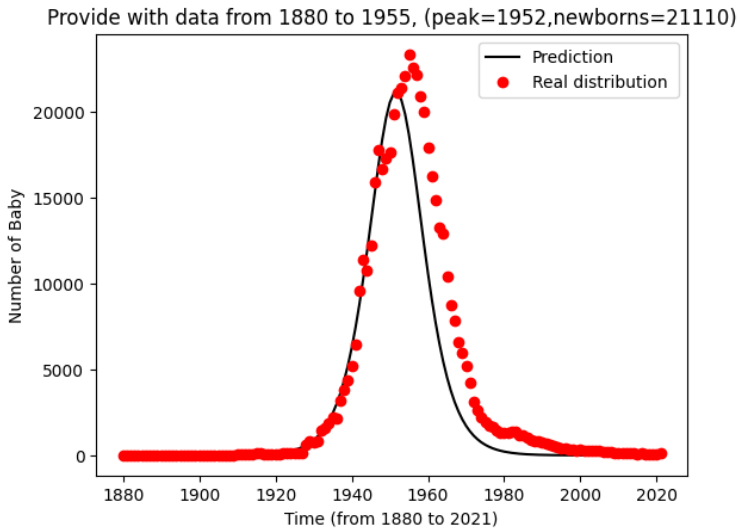
- Database : US Dataset form 1880 to 2021
- Give to the code the total database to find the best constants by minimizing the square of the errors
- Constants to find : η_0,K and q

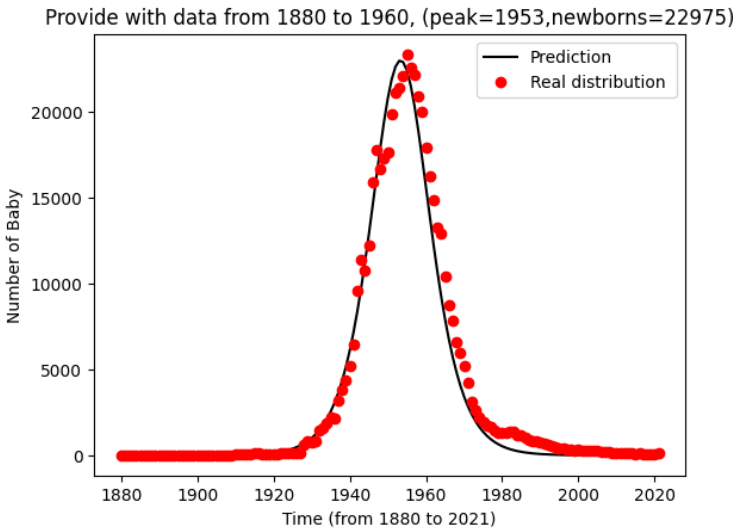


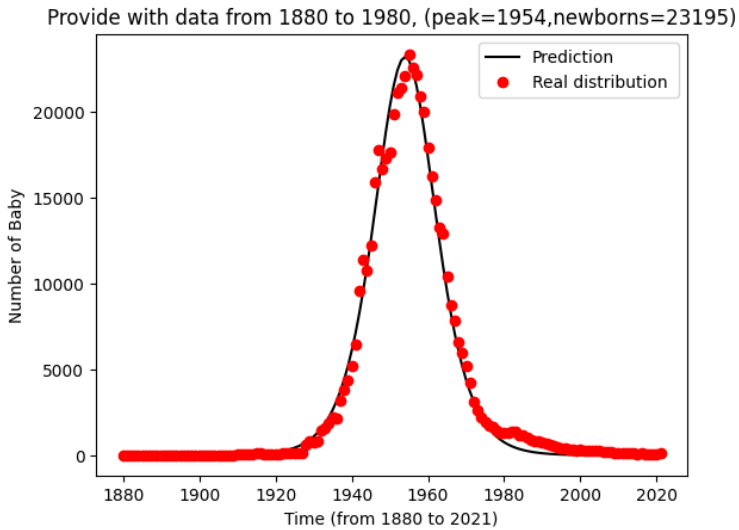
II) Bass Model for first names : Prediction

- The Name Diane : Peak in 1955 with 23345 newborns
- Provide the code with only the data from 1880 to a time t





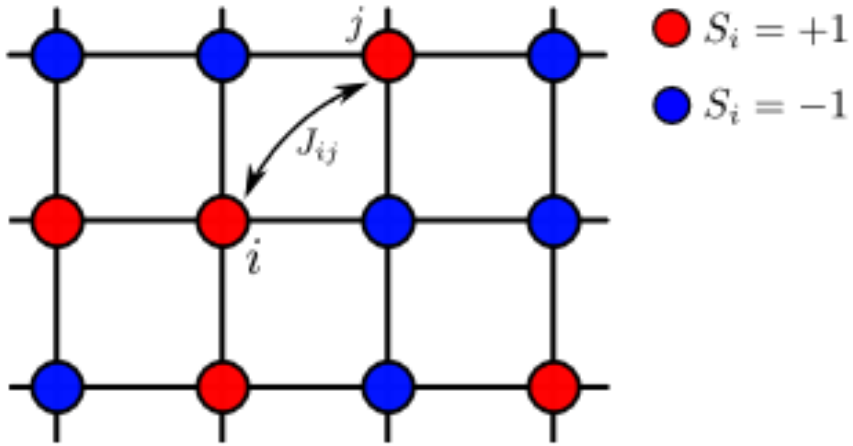




II) Effect of Media Coverage : RFIM

- The Random-Field Ising Model (RFIM) was introduced to explain the magnetic properties of random systems

$$+1 \Rightarrow \textit{name}\ 1 \text{ and } -1 \Rightarrow \textit{another name}$$



- We want the average adoption $\frac{1}{N} \cdot \sum_i s_i$ knowing that $s_i = sign\Big(f_i + h + \frac{J}{N} \cdot \sum_i s_i\Big)$

II) RFIM Model : To discuss media coverage

- How the media coverage affects the dynamic of first names ? h represent the media coverage, it's the p of Bass Model
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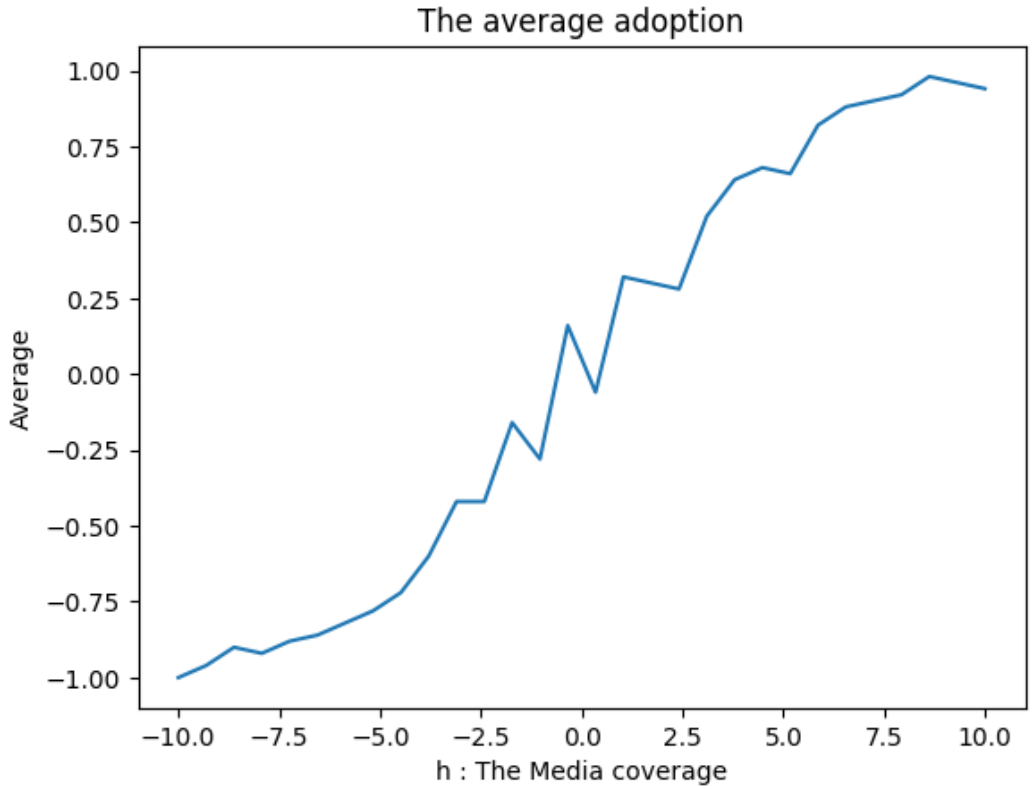
- We assume that : $f_i \hookrightarrow \mathcal{N}(0, q)$ The Standard deviation is the imitation coefficient q of the Bass Model



III) Conclusion

- Many models have been proposed but did not allow both to account for the dynamics and to have a good prediction(empirical and mechanistic model).
- By analogy between the dynamics of incidences and the diffusion process developed in economics, the two-parameter of Bass model has been developed.
- Our simulations on that model showed that the more data given to the training, the better is the prediction.
- The Bass validated for several first names because it allows to account well for the dynamics of fist names and does not have many parameters to estimate.