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W KRAKOWIE

The dynamics of divorces: socio-economic models of different societies

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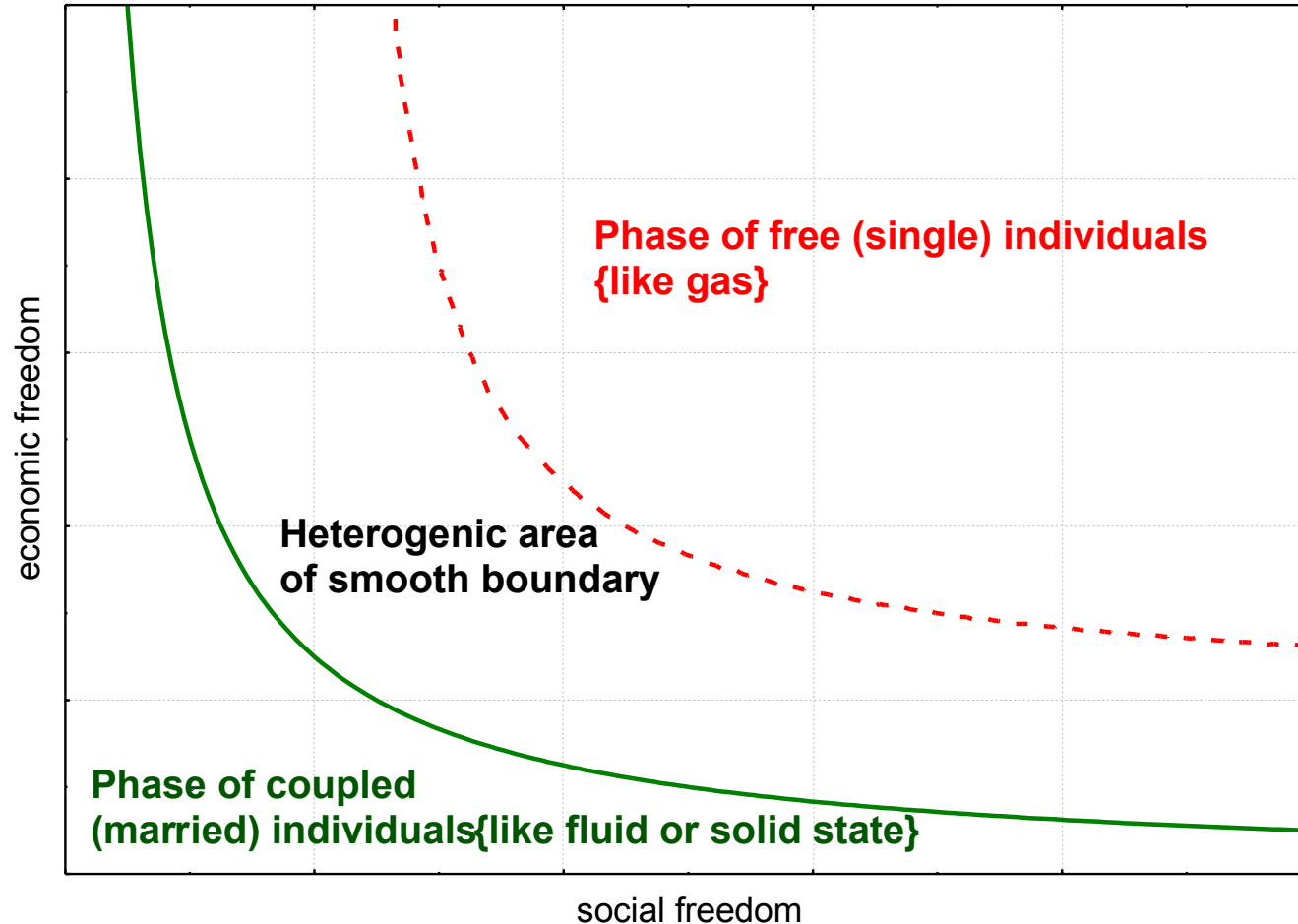3 Complex System Group, University of Science and Technology, Cracow

- **Theoretical model**
- **Social change (Bouchaud's)**
- **Economic factors**
- **Political disturbance**
- **Network studies**

Coupled vs free preferential states of individuals

Phase of free (single) individuals {like gas}

Heterogenic area of smooth boundary

Phase of coupled (married) individuals{like fluid or solid state}

economic freedom

social freedom

"FREEZING A LOT, TYING A KNOT"

Let assume that marital status has its mechanistic equivalent in state of matter observed in nature. People can be in two states: free (single) and coupled (married) and are allowed to transmit between these states. **Let introduce analogy to phase transition from physics, described in general as a function of temperature and pressure.** We can observe similar patterns in people's behavior where social and economic freedom has impact on numbers of weddings or divorces.

There are also weak points of such an approach. Sensitivity to local phenomena, called idiosyncrasy, makes comparative analysis of different countries difficult. Demographic structure of society changes in time, and is different for each country.

Our approach looks into only divorce numbers or rates in different countries. **Economic pressure or freedom of people living in different regions can be measured directly** (*e.g.* salaries, average space per person and other indicators easily accessible from statistical comparative reports). **Unfortunately there is no direct measure of social freedom or pressure**.

"FREEZING A LOT, TYING A KNOT"

Let's define that state X of every person in population can be in two states: 1– single or -1 – coupled. Dynamics of change of state of person i can be phenomenologically described as:

$$E_i(t) S_i(t) = T_i(t)$$

Where: $E_i(t)$ is an economic freedom which can be for *e.g.* linear reaction on salary;

$S_i(t)$ is a social freedom which depends on many factors like social norm level, susceptibility on social pressure or influence of other people;

$T_i(t)$ is a total freedom and indicates if person should stay or change state so it has to be compared with the threshold value for every individual.

In this work both economical freedom and social freedom are estimated separately.

We assumed that observation of dynamic (particularly growth) of divorce rate in many countries **can give us insights how social pressure collapsed in last 50 years.** There are some sociological theories of observed privatization of religion and social life at all, which concluded with stopping obeying church or social authorities (in all of biggest world's religion divorces are in particular forbidden). Nonlinearity of divorce rate change can be produced by feedback loops between social norm's change and people's behaviour.

Collective effects induced by imitation and social pressure were analysed many times for different areas of social life. Shifts of opinions can occur either abruptly or continuously, depending on the importance of herding effects, sometimes called Zeitgeist in literature. Particularly interesting and generic "Random Field Ising Model" (RFIM) has been primarily successfully proposed to model hysteresis loops in random magnets. **The model was easily translated to represent a binary decision situation under social pressure, influenced by some global information. Hamiltonian on such a system is calculated from neighbourhood of every agent.** In the first approach lattice network is proposed but other network structure can be applied like: "Small World", scale free or standard random networks.

Social norm change

In general, social freedom can be described as (when economic freedom is negligible):

$$T_i(t) = S_i(t) = \phi_i + F(t) + \sum_{j \in D_i} J_{ij} X_i$$

Where: Φ_i is an individual susceptibility on social pressure;

$F_i(t)$ is a power of social norm and can be understand as a external field;

J_{ij} is a power of relation between individuals i and j which for simplification can be unified to one value J for every pair;

D_i a neighbourhood of individual i.

Transmission driven by social pressure (freedom) can have two main realizations:

a) with domination of social norm (J~0) - when polarization of opinion changes smoothly with a time dependent social pressure;

b) with domination of imitation effect (J>>0) - when decisions change dramatically with a certain threshold value.

Mean field approach allows to investigate model for well connected societies. In our analysis, we investigate an increase of number of divorces, or rather the scaling between the height h of the peak and its width w as Bouchaud did for birth rates and cell phones. The speed of change generically peaks at a certain time; **the main prediction is a scaling relation $h \sim w^{-k}$**. His two sets of data are compatible with such a prediction, with **$k \sim 0.62$ for birth rates, $k \sim 0.71$ for cell phones**. In the mean field model, the parameter **k close to 1 corresponds to model a) with a simple pressure function**, but **close to 2/3 calls for model b) with imitation**.
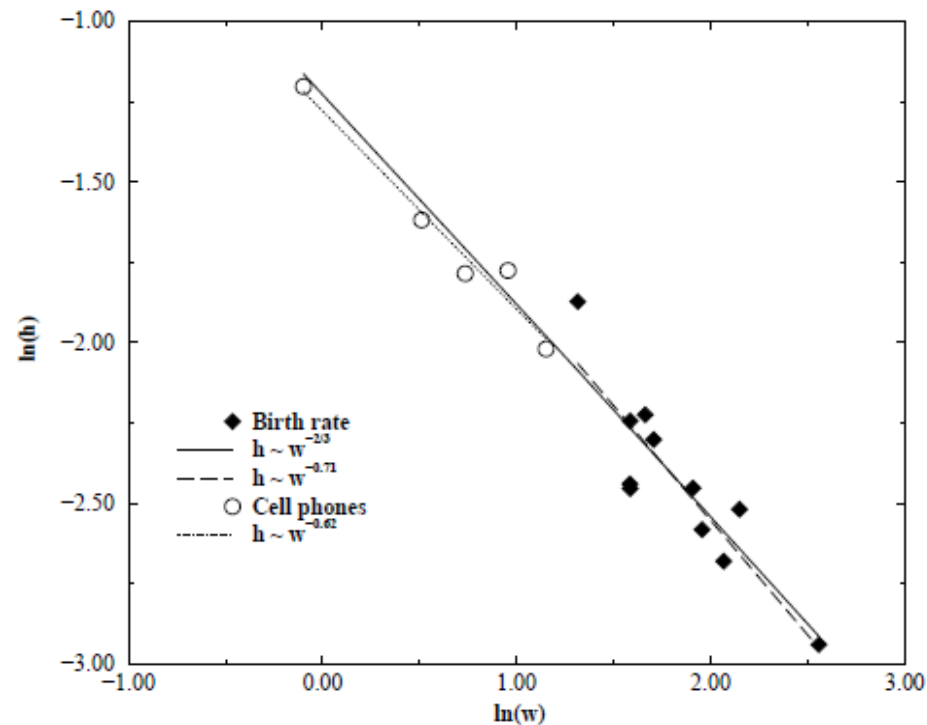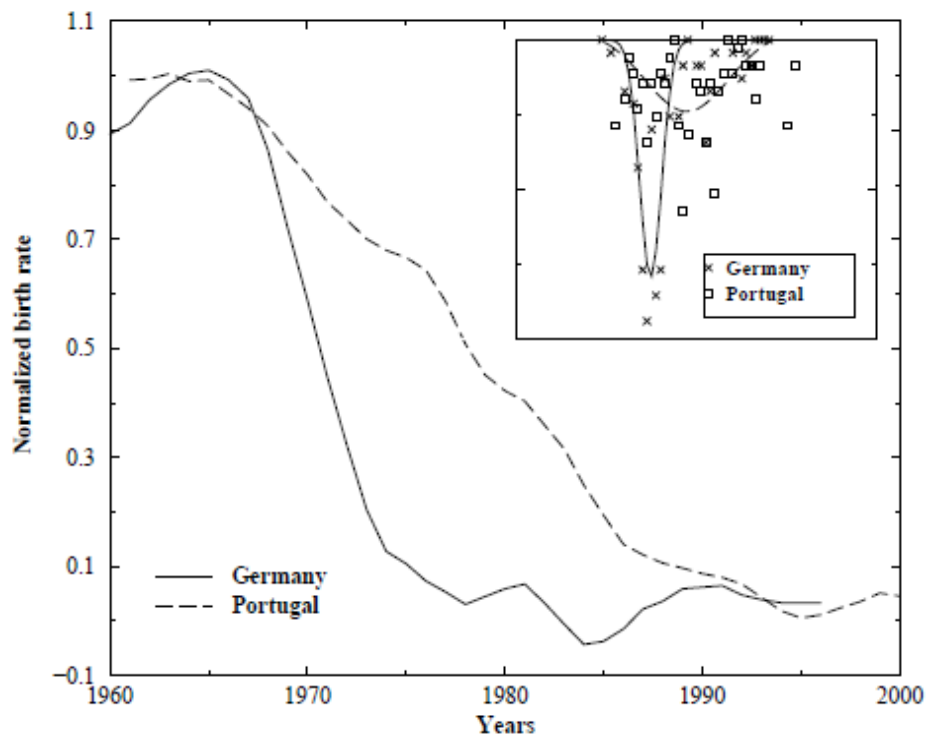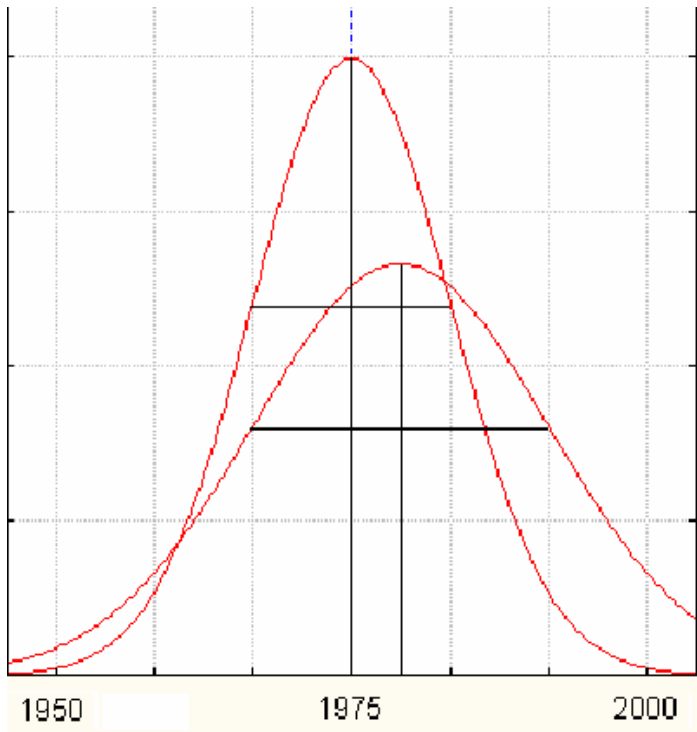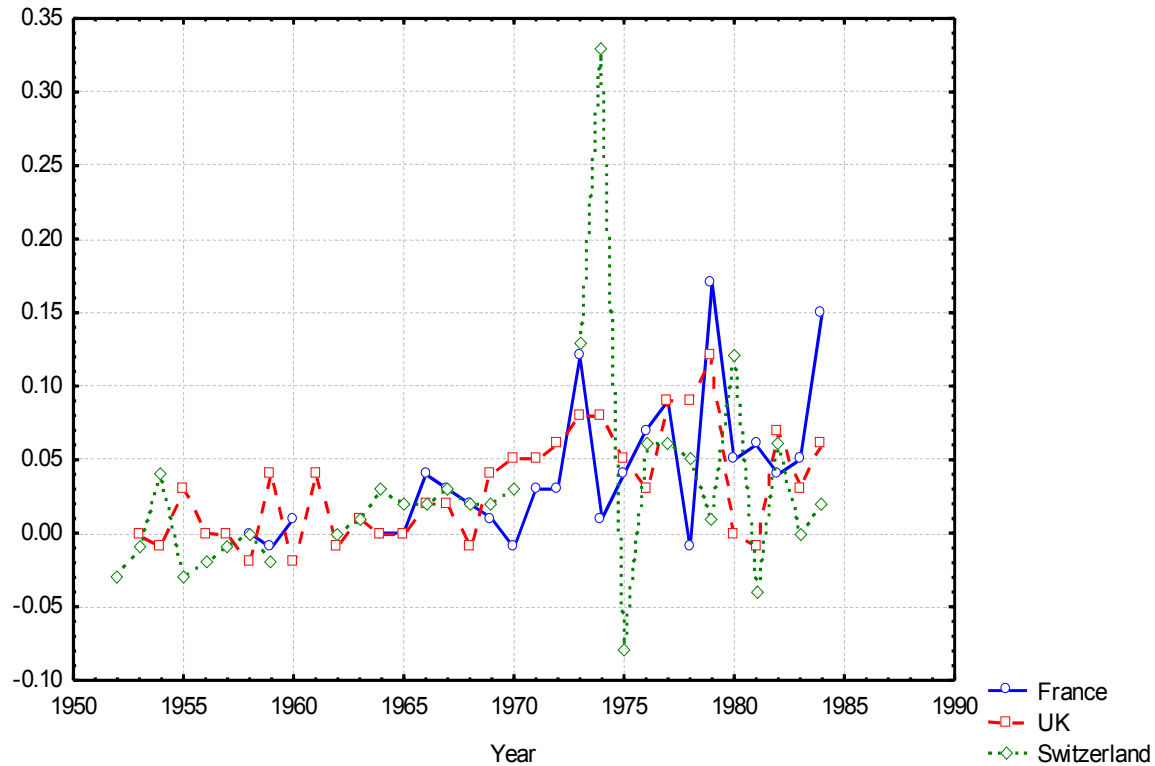
Birth rates in time [J-P. B.]   **Scaling, births and cells[J-P. B.]**

Rate of change of divorce for few good-looking countries

Ideal fitting procedure (left) and some real trajectories of divorce rate (right)

There are two estimators of w and h for each country: Inverse variance method, based on the calculation of volatility of data, were firstly introduced to estimate w and h. Bayesian method uses different cumulated percentiles of data distribution and integrates over all possible cases. Second (Bayesian) estimator seems to be more mathematically correct but more naive approach (inverse variance) fits better. Generally both estimators do not fit data successfully, so we conclude that pure sociological approach does not describe marriage-divorce phenomena.
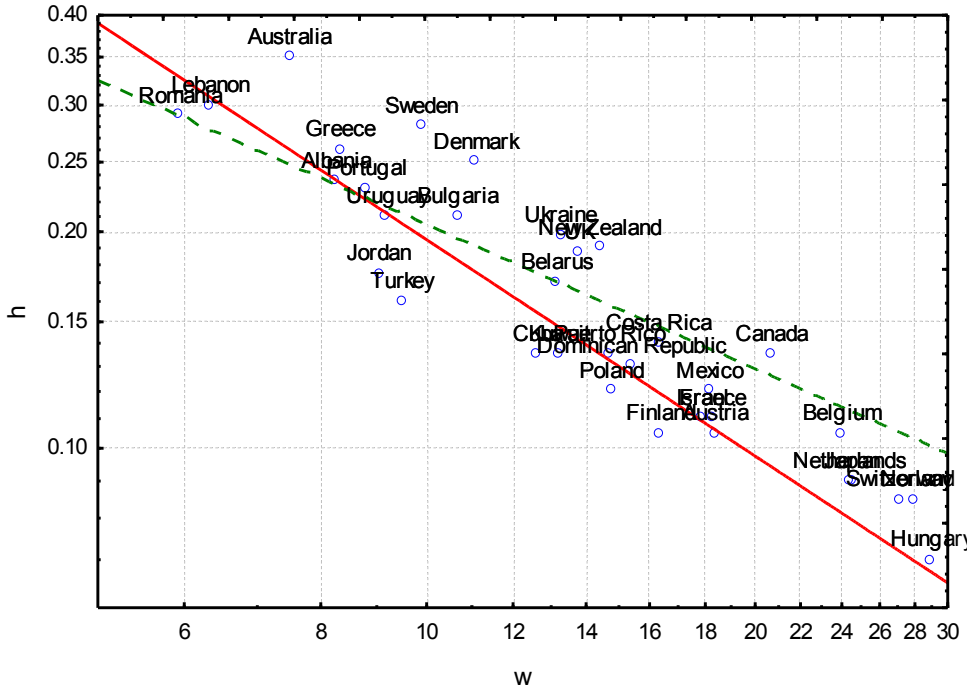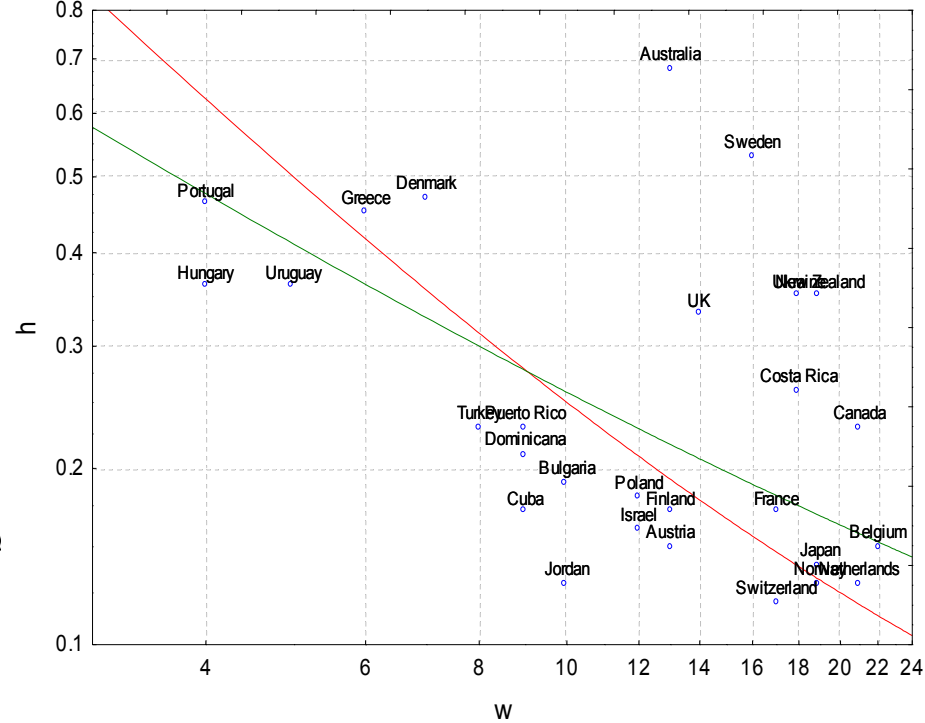
Inverse variance (left) and Bayesian method (right)

We run regressions on Polish data, where the independent variable is the average salary in region and the dependent one is the rate of divorces. We assume, that social freedom is constant in whole country, so total freedom is defined as a linear reaction on income of an individual.

$$T_i(t) = E_i(t) = b_{income} \, Income_i(t) + b_{free\ el.}$$

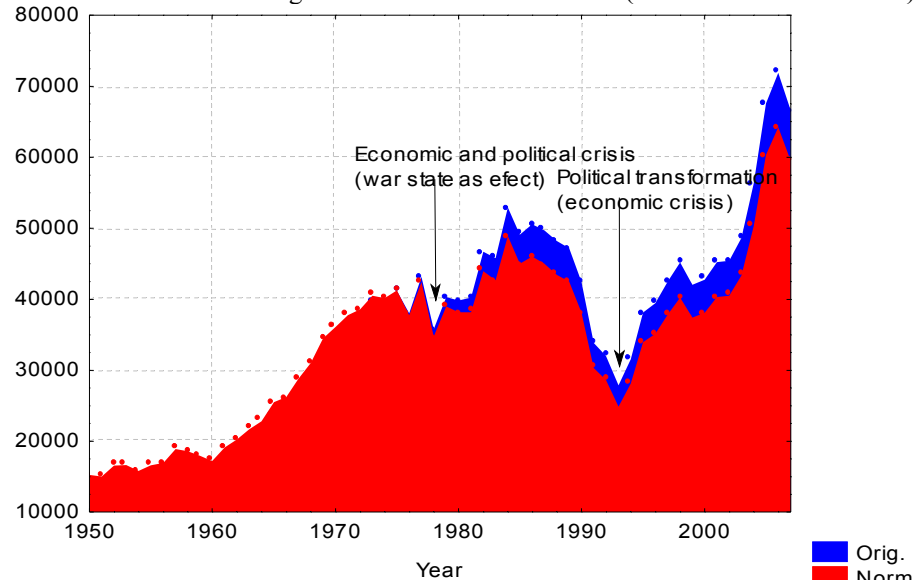Regression test for divorce rates explained by income
   grouped by Polish voivodeships for years 2011 and 2010.
   P-Value of test of explanatory variable is above any
   reasonable confidence, so relation is insignificant.

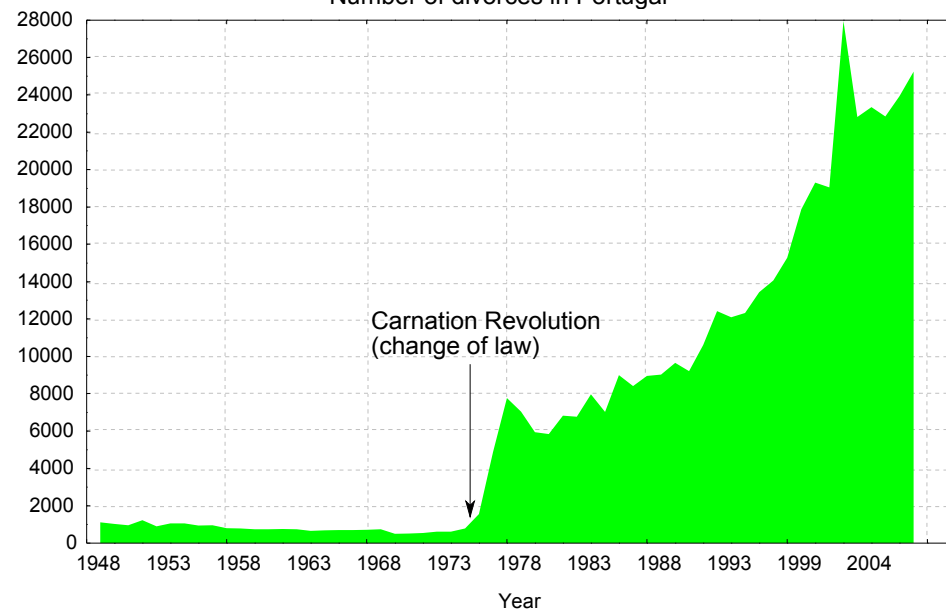| N=34	b	err. b	t(32)	p-Value	
Free el.	1.86	0.64	2.69	0.01	
Income	0.00	0.00	0.28	0.78	

Other problems appear if law of politics change. Carnation revolution in Portugal or Political transformation in Poland brought crucial influence on divorce dynamics. Salazar's regime breakdown concluded with creating new, more liberal law, which allowed people to divorce, because earlier it was almost impossible, and divorces grew dramatically. On the other hand, in Poland, when economic and political situation were bad, numbers of divorces fall down, because people were looking for help from partners in such times .

Divorces in Poland ■ original data ■ normalized data (to total no. of inhibitans)

Economic and political crisis (war state as efect)

Political transformation (economic crisis)

Orig.
Norm.

Year

Number of divorces in Portugal

Carnation Revolution (change of law)

Year

Regression test for divorce rates explained by support to **national conservative party** ''PiS'' grouped by Polish voivodeships during parliamentary elections in 2011. P-Value of test of explanatory variable is below any reasonable confidence, so relation is significant and negative.

N=17	b	err. b	t(15)	p-Value	
Free el.	3.32	0.25	13.32	0.00	
"PiS" supporters	-0.04	0.01	-5.31	0.00	

Measuring social and economic freedoms at once is extremely difficult. We proposed **indirectly pure social** or **direct pure economic** estimates but both do not explain phenomena separately. **Norm changes, easily explained by Bouchaud's model to cells sells or to decision on having children is not seen explicit in divorces dynamics.** One of the biggest factor of mismatching methods is demography (especially of postwar Europe). Number of people was permanently growing with different speed. Age-structures of societies were also changing in time. Rich countries gained big amount of immigrants in waves. Cell phones sells dynamics have reached saturation level just in few years, so change of demographic structure did not disturb the process. On the other hand, Birth rate, which was observed for last 50 years, was operationally defined as fertility rate. **This definition allowed to avoid any problems of demographic structure, because of normalization of births to number of woman in fertile age.**

We are planning to study marriage-divorces mechanism on spatial-temporal networks. There is a possibility to go even further and look **into „single-in relation" transition for non registered couples.** Such a information could be collected **via Facebook or surveys**. We can measure directly economic freedom (usually as an average salary in region in time series or sometimes even on individual level) but the social pressure must be defined. In our work we used Bouchaud method which enables us to obtain social factor but not in time series. We had to look at 40-50 years time interval to deduce value of social pressure change. Even worse, those disadvantages of Bouchaud's methods has just a small impact in comparison with non-compliance between theory and data. This global approach fails. We could look then on dynamics of **society networks where nodes would be individuals and links would be marriages or relations**. Those individuals would be exposed to local socio-economic redefined factors and agent based modeling would be applied to compare with real processes.

Thank you for attention!

http://th.if.uj.edu.pl/~gulakov