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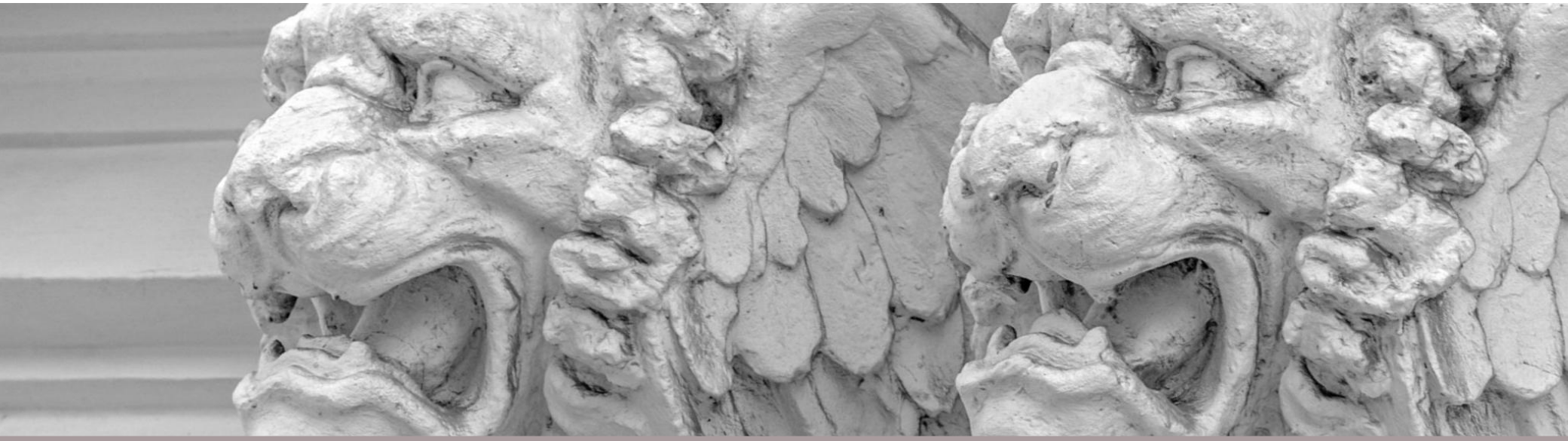

Assessing mortgage risks using big data

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Financial Stability Department

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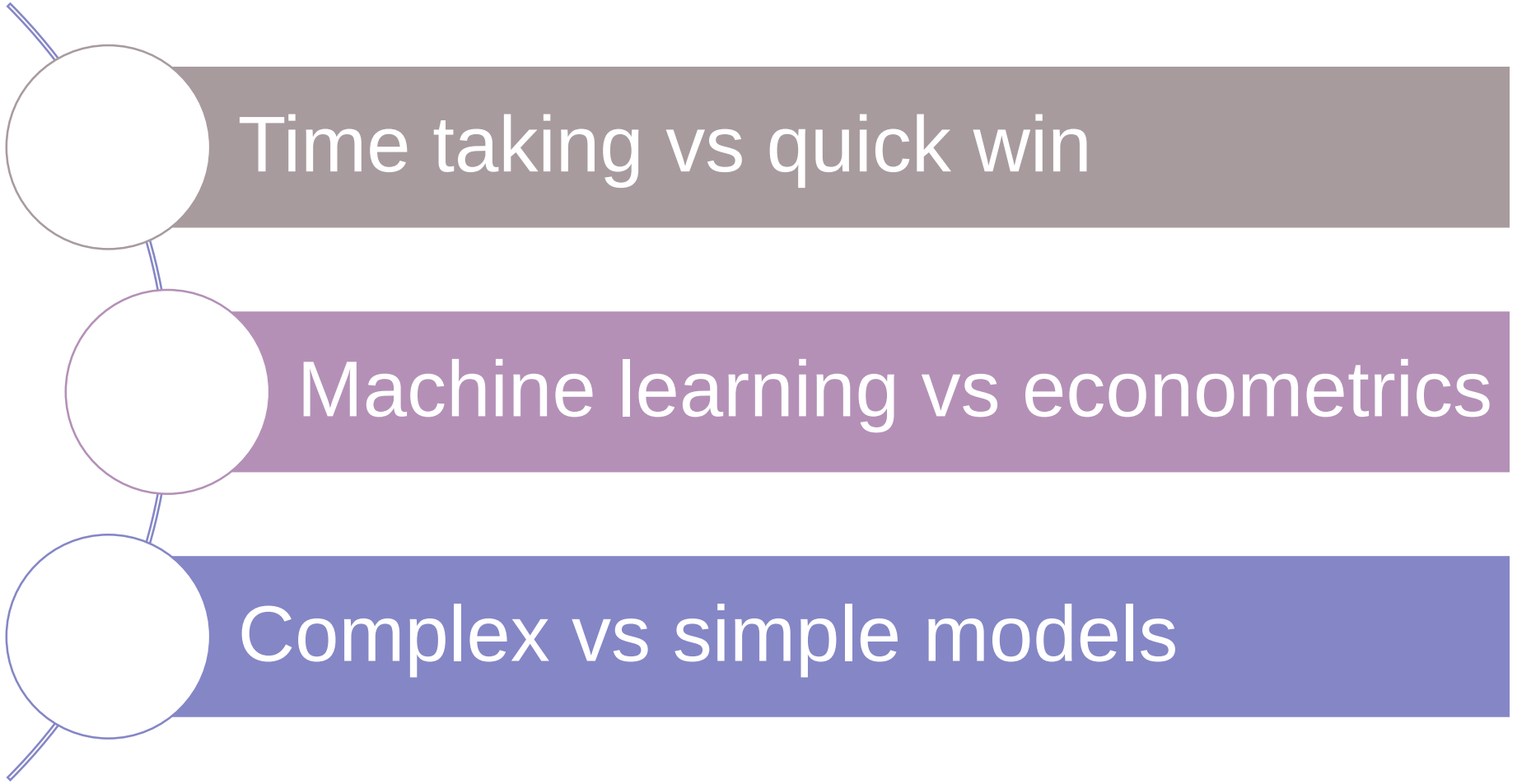
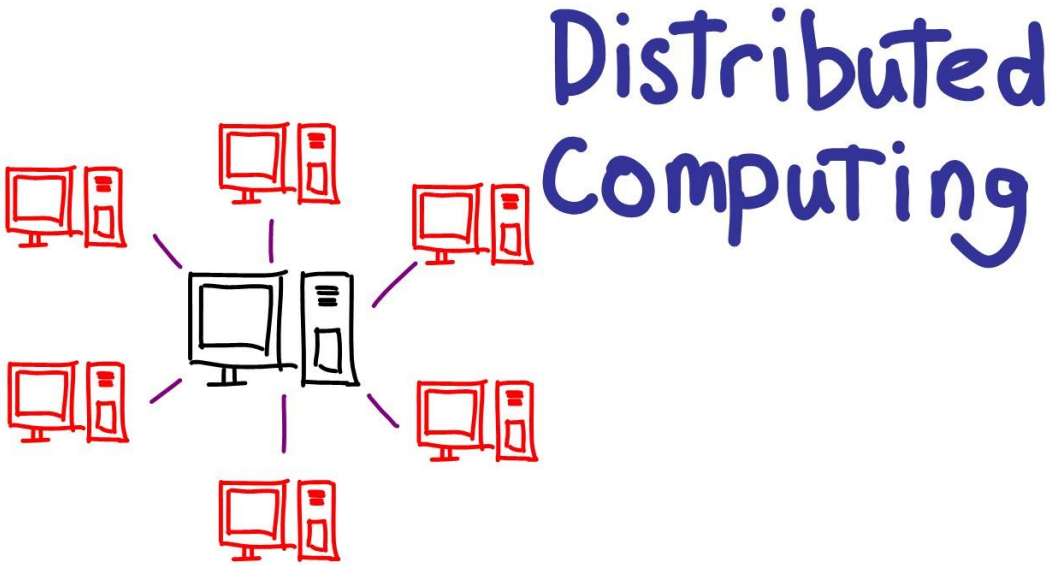
Big data and machine learning challenges



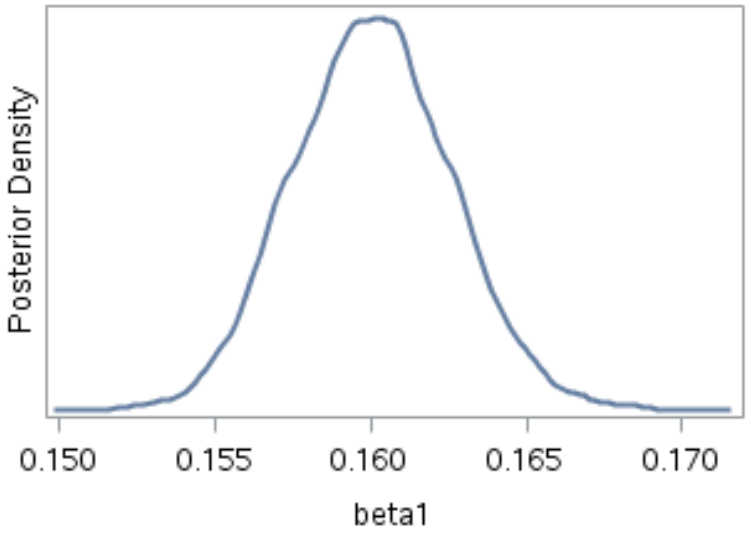
Time taking vs quick win

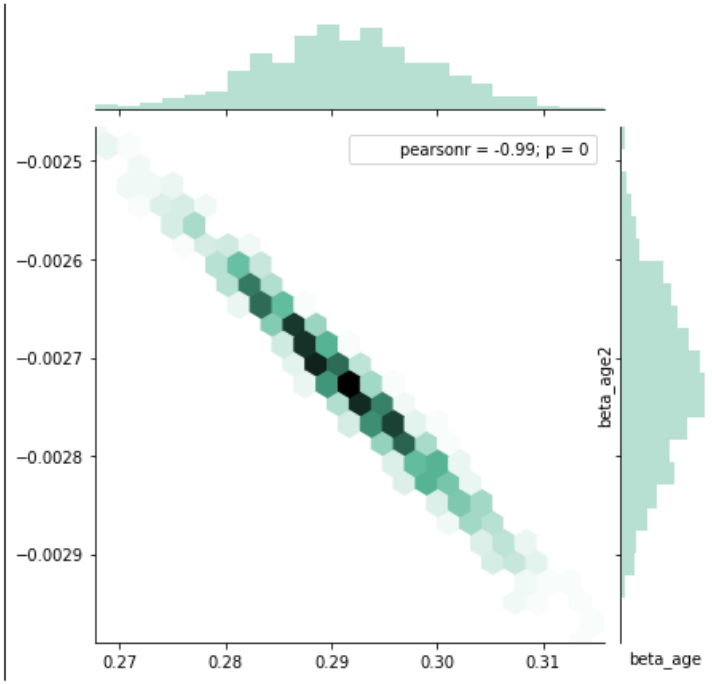
Parallel computing or distributed processing of large data sets across clusters or computers



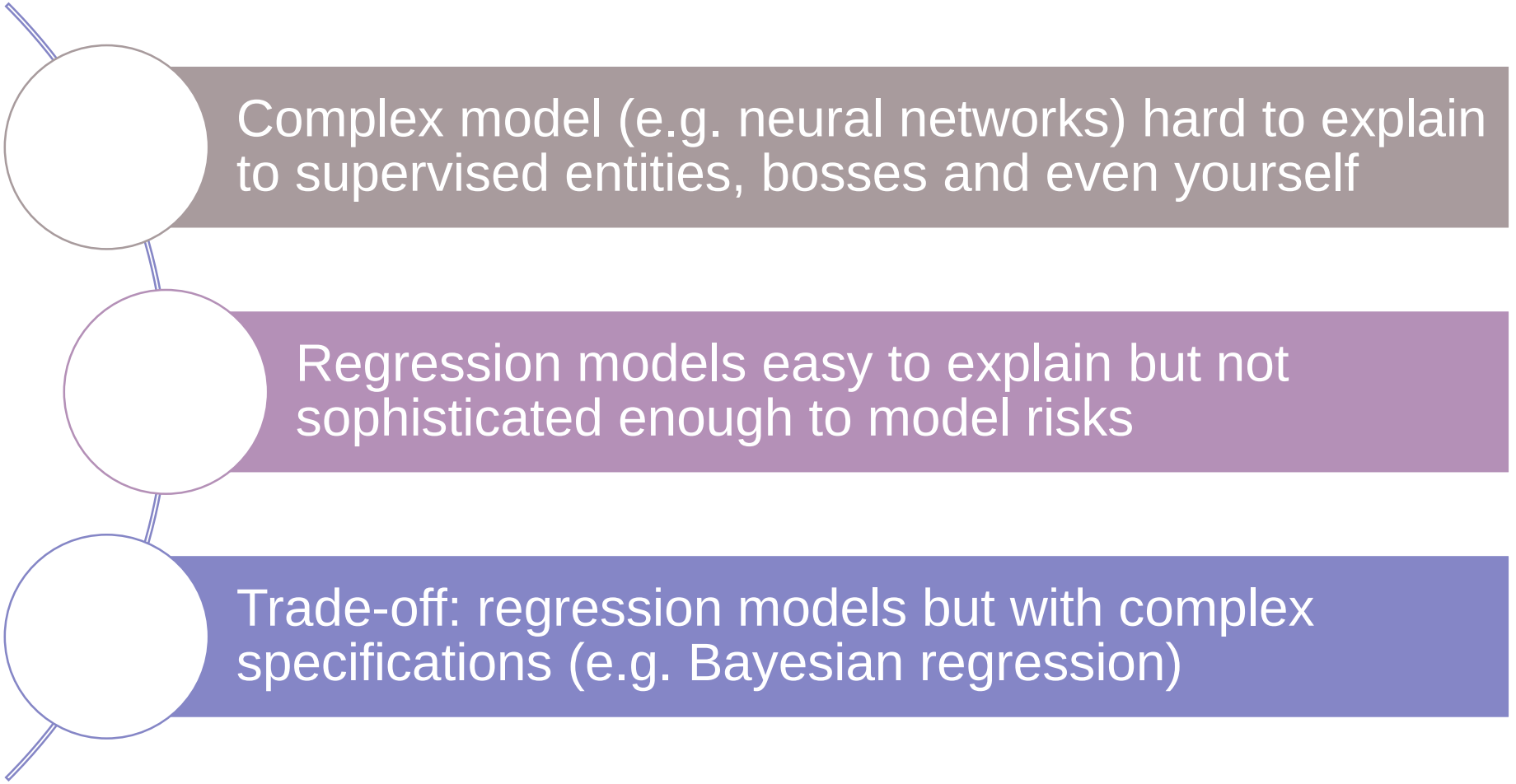
Machine learning vs econometrics

- ML includes larger variety of models (clustering, regression models (also hierarchical), neural networks etc.)
- No normality assumptions (use appropriate distribution for modeling even constructed by yourself and get non-normal posterior distr.)
- Deal with correlated covariates using Bayesian MCMC approach and take away posterior distr.
- Work with distr., not point estimates





Complex vs simple models



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Mortgage credit risk assessment in BoR

Data for mortgage credit risk analysis

Participants: six banks (covering more than 80% of the whole mortgage market).

Aggregated monthly data since 2007 till 2018: portfolio, issuance, transitions (over 70 mln. records).

Covariates: issuance date, state (region), collateral, currency, Current Loan-to-Value ratio, Payment-to-Income ratio, #household members, days past due.

Data template for loans migration

Report date	Vintage date	Currency	Collateral	State (region)	Prev. segment Index	Curr. segment Index	Loans outstanding	# Loans
01.01.2007	01.01.2007	Local	Real estate	1	LTV', PTI', CTI', DPD'	LTV, PTI, CTI, DPD		
…	…	Foreign	Claims Under Share Construction Participation Agreements	…				
01.01.2018	01.12.2017			11				

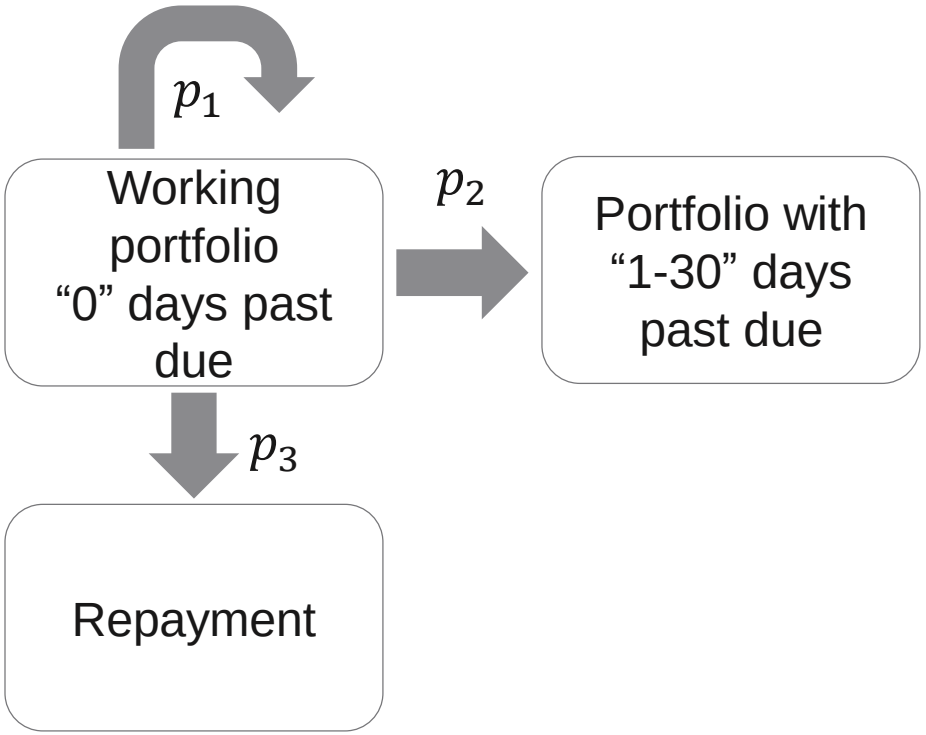
Notes:

$$\text{Consumption}-\text{to}-\text{Income (CTI)} = \frac{\#\ \text{household members} * \text{minimal allowence}}{\text{Income}}$$

LTV, PTI, CTI takes discrete values from 0 to 100% with step 10 p.p.

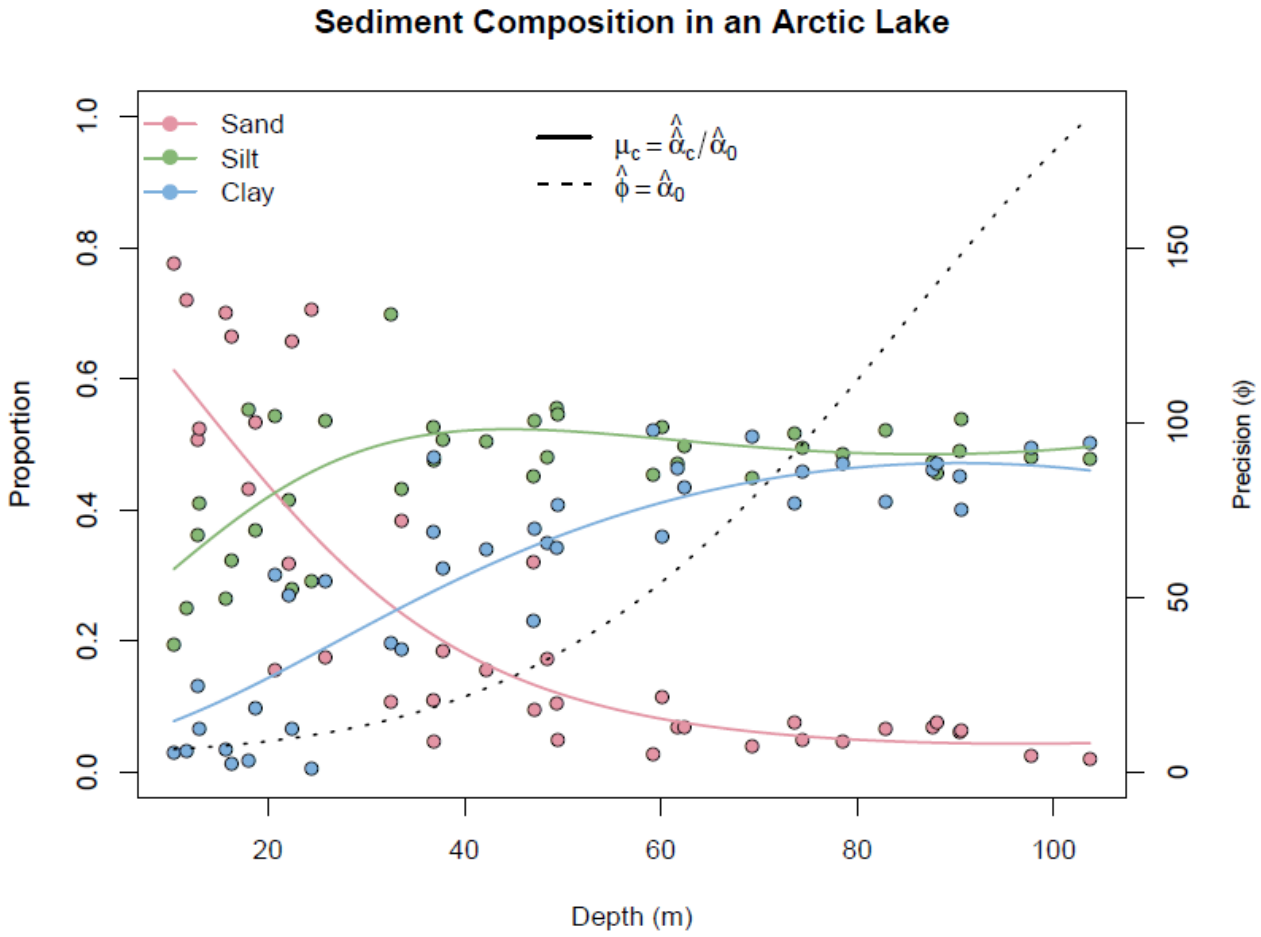
Days past due (DPD): "0", "1-30", "31-60", "61-90", "91-120", "121-150", "151-180",
"180-360", "360+" and "write off", "sell", "repayment".

Credit portfolio modeling



$$\sum_{i=1}^{3} p_i = 1$$

Compositional data



We use Dirichlet regression to deal with composite data (see M.J. Maier 2014)

$$f(\boldsymbol{p}|\boldsymbol{\mu},\varphi) = \frac{1}{B(\boldsymbol{\mu}\varphi)}\prod_{i=1}^{C} p_i^{(\mu_i\varphi-1)}, \qquad \mu_i \in (0;1), \forall i, \qquad \sum_{i=1}^{C}\mu_i = 1,$$

$$\sum_{i=1}^{C} p_i = 1\,, p_i \in (0;1), \forall i \qquad \varphi > 0, \qquad E[p_i] = \mu_i$$

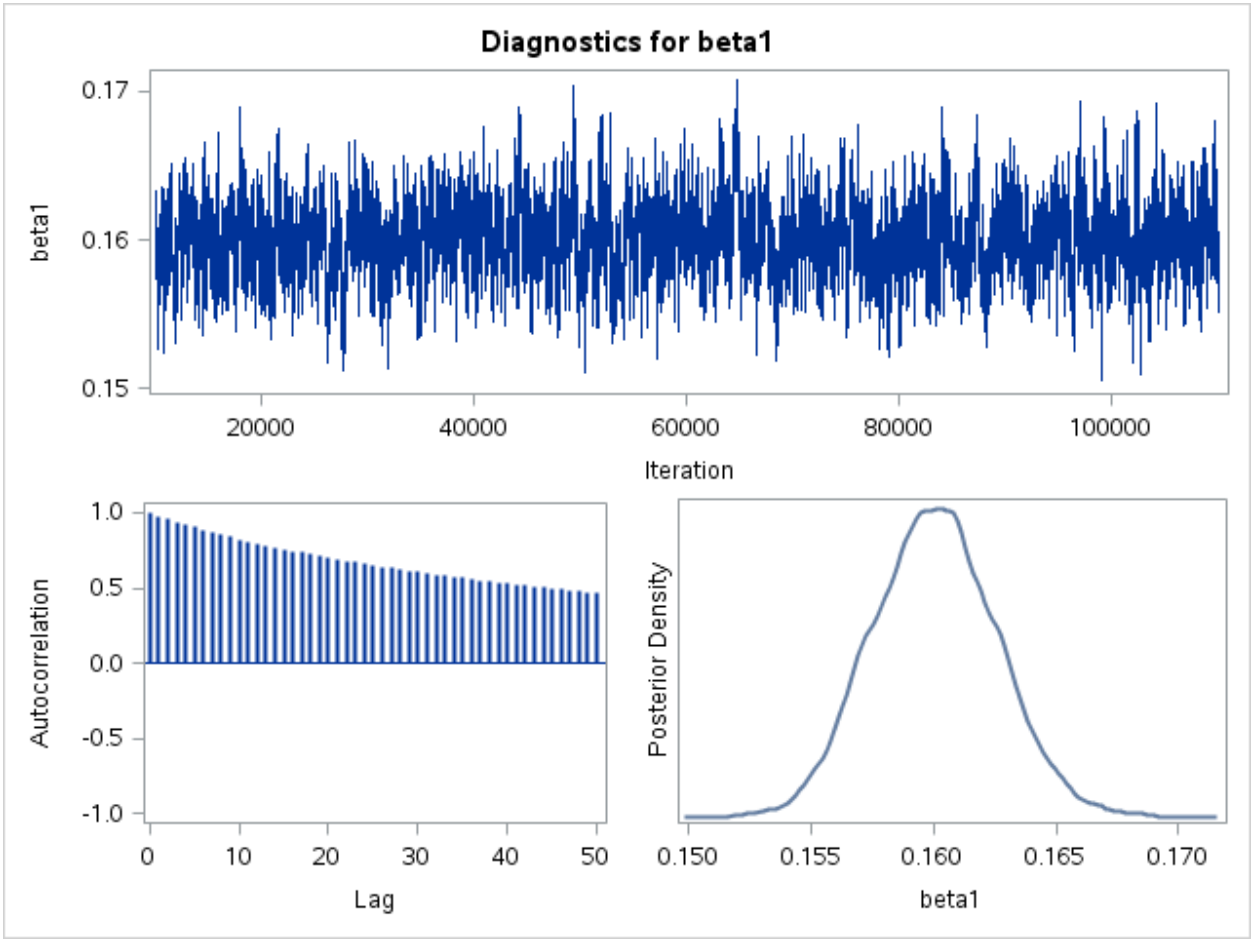
Multinomial logistic function for μ_i and exponential for φ :

$$E[p_i] = \mu_i = \frac{\exp(\boldsymbol{X}\boldsymbol{\beta}_i)}{\sum_{j=1}^{C}\boldsymbol{X}\boldsymbol{\beta}_j}, \ \boldsymbol{\beta}_C = \mathbf{0} \qquad \textit{Roll-rate}$$

$$\varphi = \exp(\boldsymbol{X}\boldsymbol{\gamma}_i) \qquad \textit{Precision parameter}$$

$$\boldsymbol{X} = (Current\ LTV, Discounted\ PTI,$$
$$Discounted\ Consumption\ to\ Income, Unemployement)$$

Bayesian regression model with MCMC procedure for parameters estimation (SAS proc MCMC)



Transition matrix approach

Portfolio is 4-d matrix with dimensions: LTV, PTI, Consumption-to-Income, Days past due.

$$Pfl_t(LTV, PTI, CTI, PDD)$$

Transition matrix is 8-d array with dimensions: LTV*, PTI*, CTI*, Days past due*, LTV, PTI, Consumption-to-Income, Days past due.

$$Prob(LTV', PTI', CTI', DPD' \rightarrow LTV, PTI, CTI, DPD)$$

Transition rule:

$$Pfl_{t+1}(LTV, PTI, CTI, DPD) =$$

$$\sum_{LTV,PTI,CTI,DPD} Prob(LTV', PTI', CTI', DPD' \rightarrow LTV, PTI, CTI, DPD) Pfl_t(LTV', PTI', CTI', DPD')$$

Discounted PTI and CTI on nominal income growth and inflation

$$PTI_t = \frac{PTI_{t-1}}{1 + i_t}$$

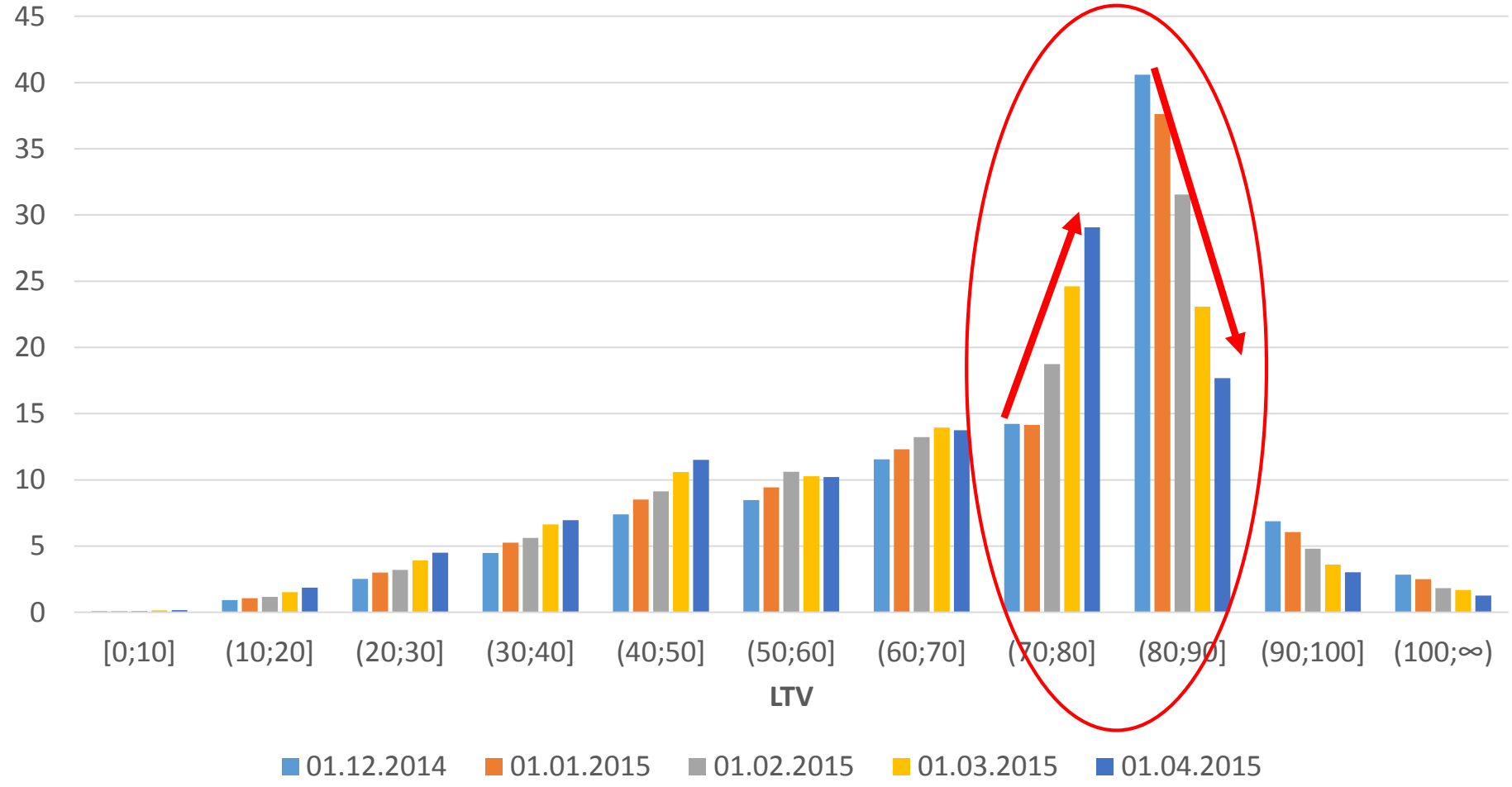
$$CTI_t = \frac{CTI_{t-1}(1 + \pi_t)}{1 + i_t}$$

i_t - nominal income growth rate by regions
π_t - inflation rate by regions

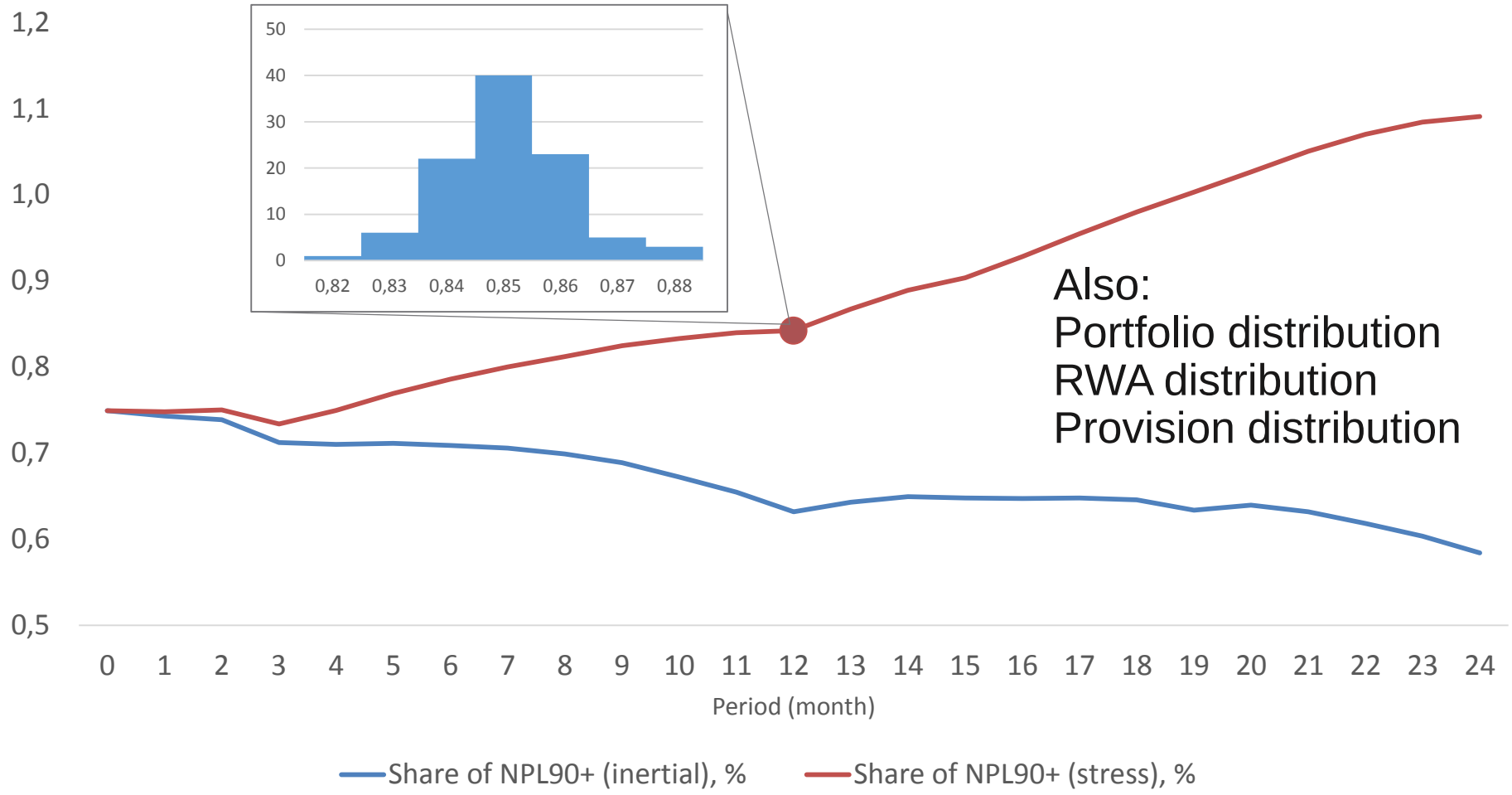
It gives Discounting matrix (4-d array):

$$Disc(PTI', CTI' \rightarrow LTV, PTI)$$

Banks constrain origination of new loans with low down payment



Example of stress-test results



Conclusions

- Big data may help to identify and estimate more sophisticated risks (behavioral aspects, concentration of risks in specific segments)
- The results of estimation may be used in macroprudential policy and under supervision
- Data scientist need to find a trade-off between simple and sophisticated models