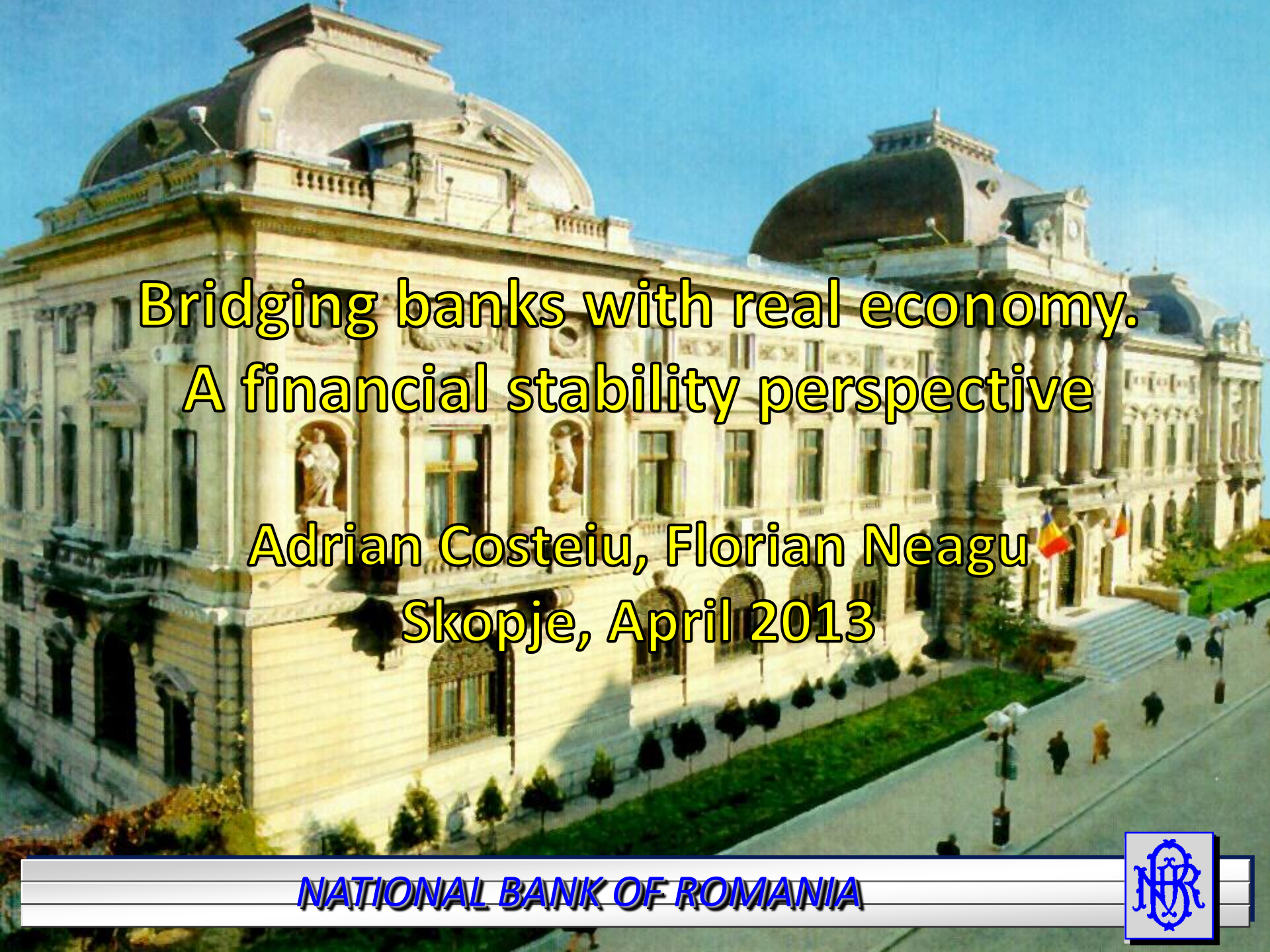

Bridging banks with real economy. A financial stability perspective

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The opinions expressed in this paper are those of the authors and not necessarily represent the views of the National Bank of Romania, nor do they engage it in any way.

I. Scope of research

II. Microeconomic model

III. Macroeconomic module

IV. Financial stability assessment

V. Concluding remarks

I. Scope of research

(i) builds a macroprudential tool to assess if the banking sector is adequately equipped to deal with micro and macro shocks;
(ii) estimates the probabilities of default for the non-financial companies sector (and test it on the Romanian case);
(iii) bridges the banking sector with the macroeconomic stance, through the corporate sector, as the link between credit risk and the business cycle has become more important;
(iv) evaluates risks to the financial stability stemming from the real sector;
(v) provides with a stress-testing framework that investigates the impact of various scenarios on the probability of default of non-financial companies.

II. Microeconomic model

Output: *one year default probability* for all non-financial companies with bank loans at the start of the period and not in default in any month of the year prior to the start of the default horizon.

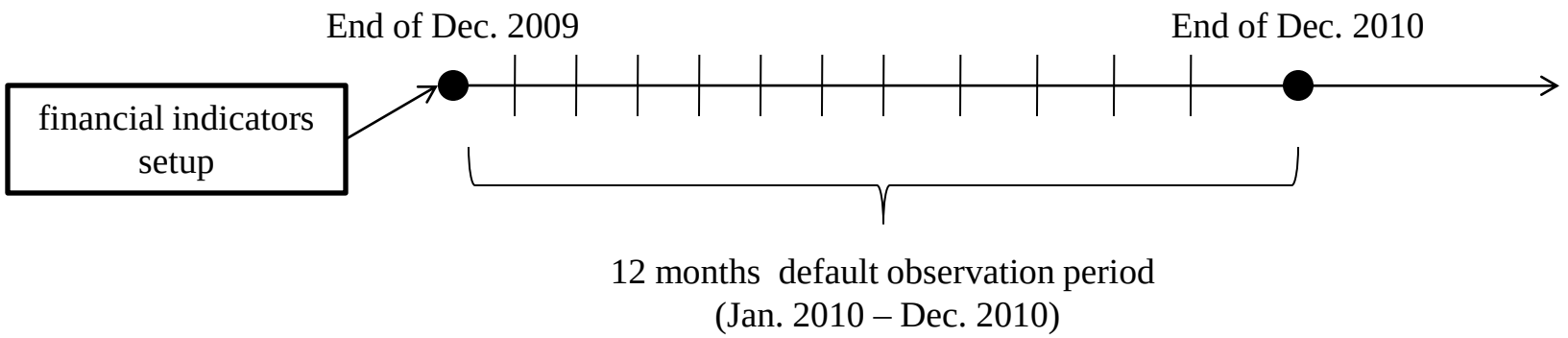
Default definition: subset of the Basel II default criteria (regulated in the EU directive 2006/48/EC and implemented by NBR in its regulation act 15/2006), *namely 90 days past due*.

Data:

- firms balance sheets and income statements (aggregated on a semi-annual basis by MFP)
- default data (collected from the Central Credit Register)

Estimation: *logit methodology* in order to estimate the probability of default of non-financial companies using as explanatory variables firms' financial characteristics prior to default.

II. Microeconomic model - overview



New defaulters as a percentage of total defaulters:

Mo.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2010	10.2	8.6	9.3	8.4	9.8	7.9	8.5	8.2	8.1	7.6	7.3	6.2

II. Microeconomic model – explanatory variables

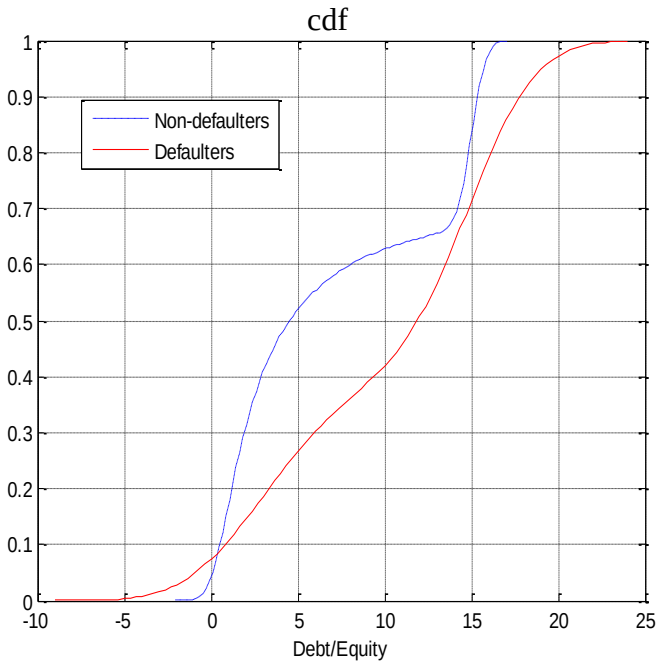
Total number of explanatory variables: **113**

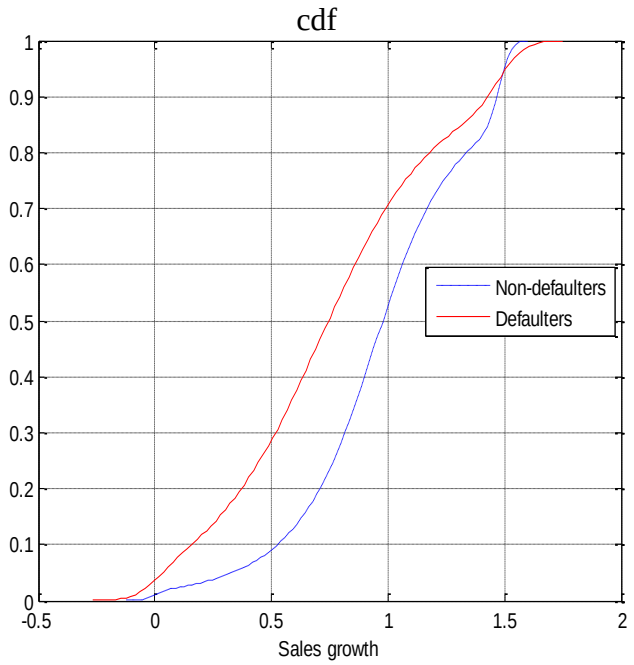
Univariate level:

- Filtering explanatory variables using **4 tests**:
  1. *Kolmogorov-Smirnov*
  2. *Linearity and monotony test*: the logit requires that the *log(odds of default)* be linear and monotonous with the variables
  3. *Discriminatory power test* – we drop variables with AUROC<53%
  4. *Multicolinearity test* – we drop the least powerful variable out of any pair with a correlation coefficient grater than 0.7

II. Microeconomic model – Kolmogorov-Smirnov Test

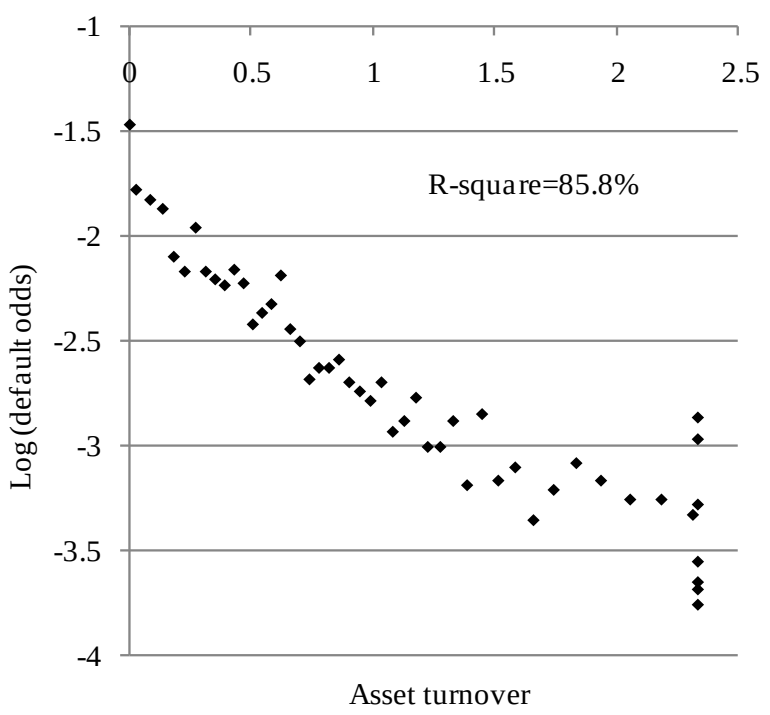
- The KS statistic is a generic test to see whether or not two data samples come from different distributions.
- Within the context of default risk prediction, the two data samples refer to the defaulter and non-defaulter data samples.

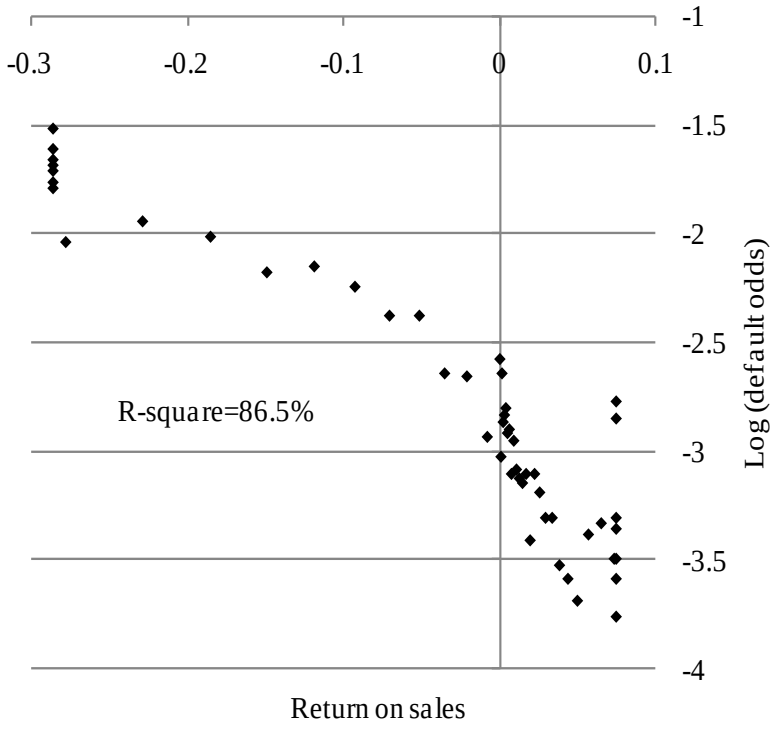




II. Microeconomic model – Linearity and Monotony Test

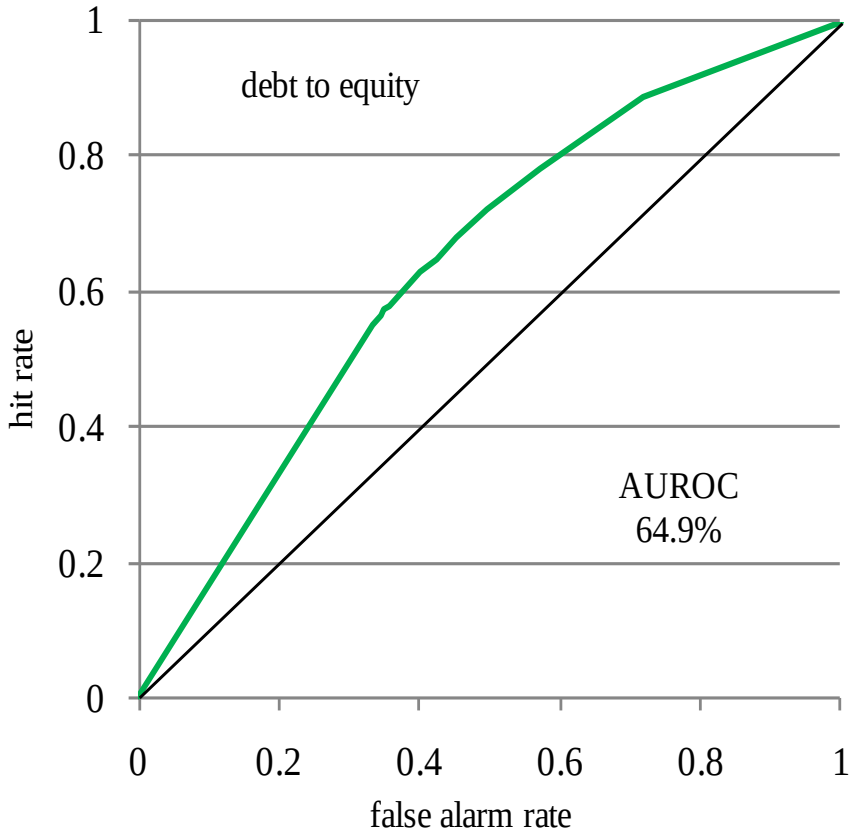
Log (odds of default): $\log \frac{P(y_i = 1)}{1 - P(y_i = 1)} = \alpha + \beta x_i$





II. Microeconomic model – Discriminatory Power Test

AUROC – Area under the ROC curve



$$HR(C) = \frac{H(C)}{N_D}$$

H(C) the number of defaulters classified correctly for a given threshold C

N_D the total number of defaulters in the sample

$$FAR(C) = \frac{F(C)}{N_{ND}}$$

F(C) the number of false alarms

N_{ND} the total number of non defaulters in the sample

II. Microeconomic model – model estimation

Multivariate level (reduced list of variables):

- Backward logit estimation technique:
  - conduct a bootstrap exercise of 100 models using a proportion of 50:50 of defaulted to non-defaulted companies;
  - analyze the frequency of the models and variables;
  - choose the final specification based on discriminatory power;
  - re-estimate the coefficients using another bootstrapping exercise in order to obtain unbiased sample coefficients

II. Microeconomic model – results

Logit model for 1 year default horizon using **2009-2010** data

-Number of observations in the dataset used for building the model: **68,463** out of which **6,903** defaults

-Number of observations in the bootstrapping exercise: **13,806** out of which **6,903** defaults

-In sample AUROC: **84,2%**

-Out of time AUROC (2010-2011): **85,5%**

-Neutral cost policy function:

- Optimal cutoff: **7,5%**, Hit rate: **78%**, False alarm rate: **22.9%**

Variables	**Coefficient**	**Standard error**	**t-stat**
Adjusted intercept*	-1.2395	n.a	n.a
Debt to equity	0.0496	0.0045	11.4313
Debt to value added	0.0630	0.0101	6.5120
Interest cover ratio	-0.0424	0.0083	-4.2323
Receivables cash conversion days	0.0045	0.0003	14.9629
Sales growth	-0.6223	0.0622	-11.0277
<15 days past due dummy	1.6419	0.0728	22.3807
15-30 days past due dummy	2.2398	0.1064	20.6327
30-60 days past due dummy	2.8703	0.0944	30.7421
60-90 days past due dummy	3.6170	0.1341	27.4151

n.a. – not applicable

* Considering the real default rate registered in 2011

II. Microeconomic model – calibration

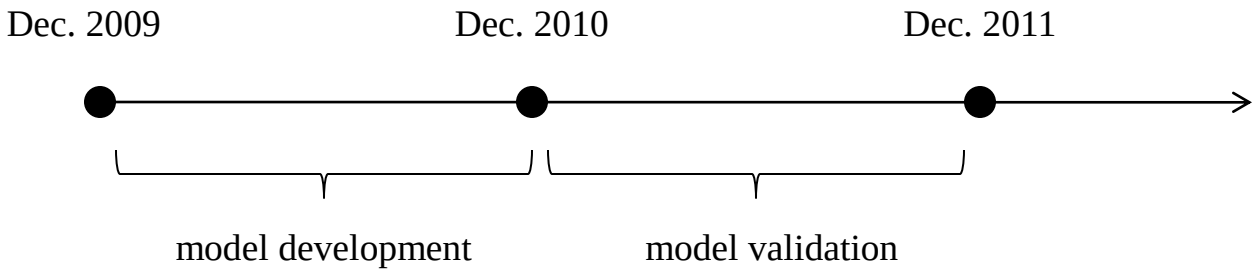
- King and Zeng (2001) - Adjustment to intercept only, MLE of β need not be changed:

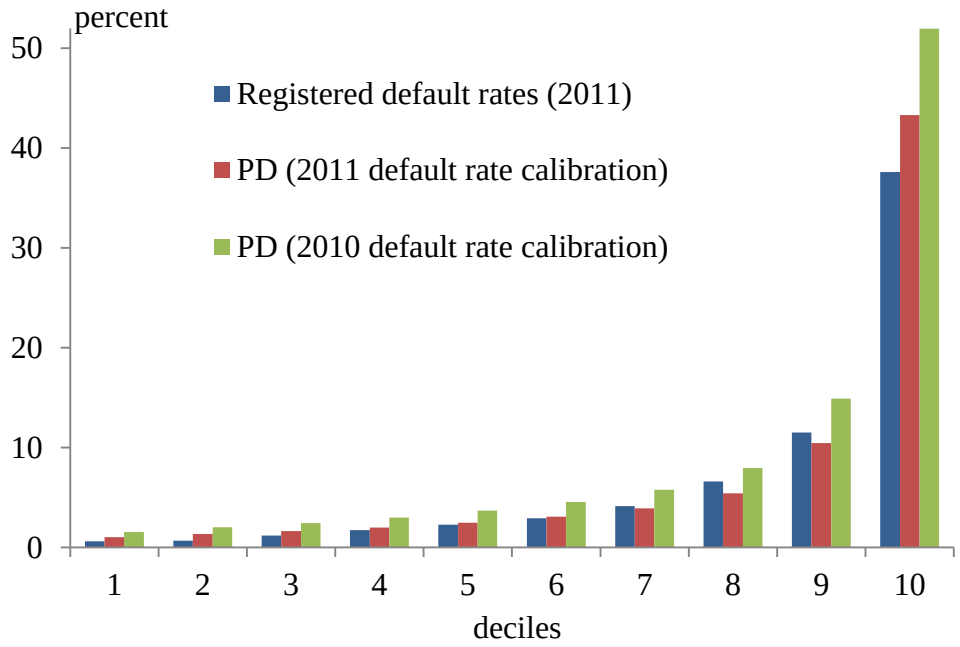
$$\log\left(\frac{PD}{1-PD}\right) = \alpha + X\beta + \log\left(\frac{\pi_d}{1-\pi_d} / \frac{p}{1-p}\right)$$

where:

- PD is the calculated probability of default
- **π_d is the default rate at which we calibrate the PD**
- p is the average unadjusted computed probability of default for the forecast sample
- X is the explanatory variables vector

II. Microeconomic model – calibration (2)





- Observation: Using the registered default rate from 2011 gives more accurate results.
- Issue: This information is not available!
- Our solution: develop a macro-economic module to estimate the default rate.

III. Macroeconomic model - overview

Calibrating the probabilities of default obtained from micro models to future estimated default rates, based on macroeconomic data, is appropriate especially for point in time analysis.

- Macroeconomic model framework: **Jakubík (2007)**
  - a default occurs if the return on a firm's assets falls below a certain threshold (T), where T can be a constant or expressed as a linear combination of macroeconomic variables.

$$p_{it} = P(R_{it} < T) = P(\sqrt{q}F_t + \sqrt{1-\rho}U_{it} < \beta_0 + \sum_{j=1}^{N}\beta_j x_{jt}) = \Psi(\beta_0 + \sum_{j=1}^{N}\beta_j x_{jt}) \quad (1)$$

  - The conditional probability of default on realization f_t of random factor at time t corresponding to the default probability is given by:

$$p_i(f_t) = P(U_{it} < \frac{\beta_0 + \sum_{j=1}^{N}\beta_j x_{jt} - \sqrt{\rho}\, f_t}{\sqrt{1-\rho}}) = \Psi(\frac{\beta_0 + \sum_{j=1}^{N}\beta_j x_{jt} - \sqrt{\rho}\, f_t}{\sqrt{1-\rho}}) \quad (2)$$

III. Macroeconomic model - overview

- The random factor is assumed to be independent between the borrowers.
- The number of defaults $D_t(f_t)$ at time t has a binomial distribution with conditional default probability $p(f_t)$ and the given number of companies N_t.
- Unconditional probability of having exactly d_t at time t can be obtained as an integral over the random factor:

$$P(D_t = d_t) = \int_{-\infty}^{\infty} \binom{n_t}{d_t} p(f_t)^{d_t} (1 - p(f_t))^{n_t - d_t} \phi(f_t) df_t \qquad (3)$$

- Parameters ρ and β are estimated by maximizing the following log-likelihood function:

$$l(\beta_0, \ldots, \beta_N, \rho) = \sum_{t=1}^{T} \ln \left\{ \int_{-\infty}^{\infty} \binom{n_t}{d_t} \Psi\left(\frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}} \right)^{d_t} \left[1 - \Psi\left(\frac{\beta_0 + \sum_{j=1}^{N} \beta_j x_{jt} - \sqrt{\rho} f_t}{\sqrt{1-\rho}} \right) \right]^{n_t - d_t} \phi(f_t) df_t \right.$$

III. Macroeconomic model – variables and final specification

- **Time interval:** Q1 2001 – Q4 2011

- **Dependent variable:** quarterly registered default rate

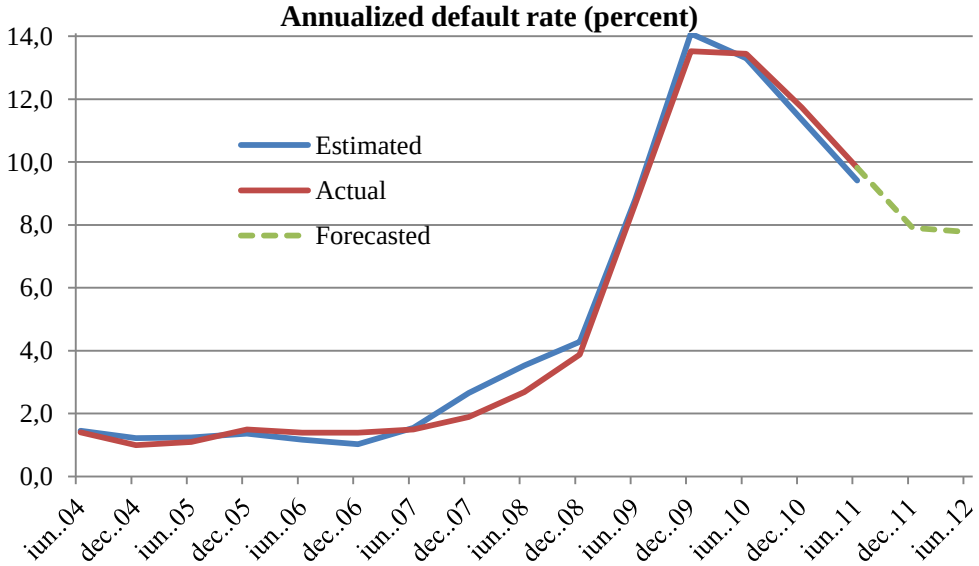
- **List of the main explanatory variables considered:**
  - GDP fluctuations
  - exchange rates
  - interest rates
  - inflation

- **Final model specification:**
  - annual GDP growth
  - real effective exchange rate
  - CORE1 annual inflation
  - the interest rate spread (domestic loans interest rate vs. 3m EURIBOR)

$$p_t = \Psi(\beta_0 + \beta_1 gdp\ growth_t + \beta_2 reer_{t-1} + \beta_3 CORE1_{t-2} + \beta_4 spread_{t-2})$$

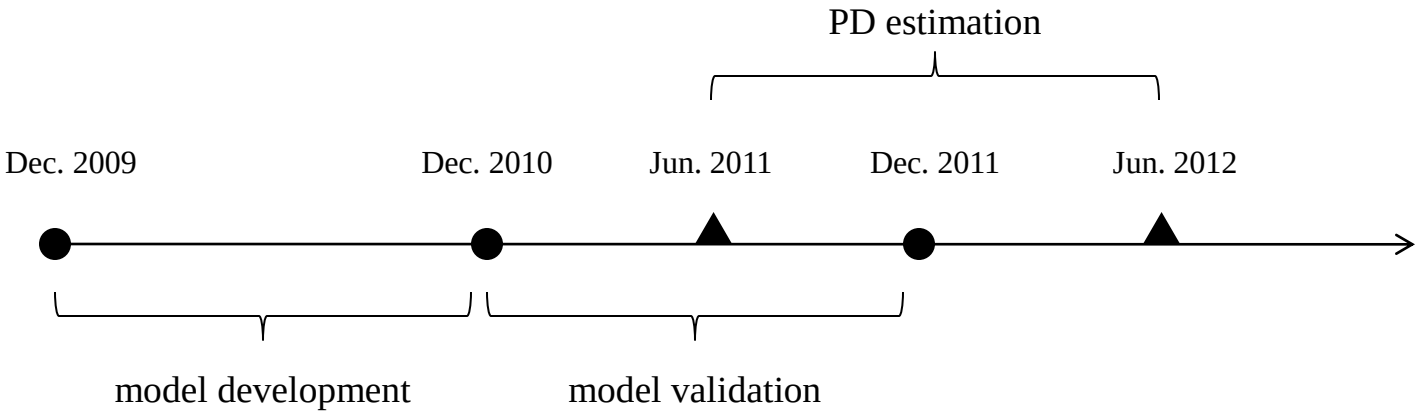
III. Macroeconomic model – results

Methodology	**Jakubík (2007)**		
Number of observations	**34**		
Number of variables	**6**		
Variables	**Lag**	**Coefficient**	**Standard error**
Constant	-	-2.0276	0.0773
GDP growth (yoy)	0	-0.0224	0.0125
Real effective exchange rate (qoq)	1	0.0906	0.0152
CORE1 annual inflation (yoy)	2	-0.0265	0.0089
Interest rate spread	2	0.0179	0.0064
ρ	-	0.0001	0.0208
R-squared	84.01		
LR - test	92.28		
RMSE	0.020		



IV. Financial stability assessment

- estimate PDs for June 2012 using semi-annual financial statements from June 2011
- calibrate the PDs using June 2011 - June 2012 forecasted annual default rate



Sector	Average PD
Construction	9%
Real estate	8%
Services	7%
Agriculture	7%
Manufacturing	7%
Trade	7%
Energy	6%

IV. Financial stability assessment

The macroprudential instrument is used to assess:

- the overall risk
- the distribution of risk at sector level in the real economy and the banking sector
- trends in credit risk
- level of stressed PDs (micro or/and macroeconomic assumptions)
- if the level of provisioning at bank level is adequate (EL<provisions)

V. Concluding remarks

- the macroeconomic module increases the performance of the PD model in terms of calibration;

- forecasting the default rate overcomes some drawbacks of the PD models like the pro-cyclicality and poor response to economic environment;

- macroeconomic stress scenarios can be translated in a top-down manner providing more accurate results.

Thank you !