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Credit Risk Evaluation in the Residential Mortgage Market

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Motivation of Research



IRB

Internal Risk-Based Approach

PD, LGD, EAD, M

The experience of developing
IRB-systems in Russian bank
practice is limited

Russian mortgage crisis 2008-2009

The importance of understanding
drivers to mortgage defaults

The shortcomings of credit risk
techniques

Stylized Facts

1. Probability of default (PD).
2. Default – 90 days delinquent.
3. The absence of the concept of ‘mortgage default’ in Russian legislation.
4. Default drivers:
 - sociodemographic information
 - terms of mortgage contract
 - macroeconomic conditions

Literature Review

Bhutta, Dokko, Shan, 2010, Federal Reserve Board

- Classical binary choice models (**single-equation models**)

Follain (1990, AREUEA Journal); Rachils, Yezer (1993, Journal of Housing Research)

- Mortgage lending process consists of related or sequentially dependent mortgage lending decisions (**multiple-equation models**)
- **Theoretical model** of mortgage lending process consists of multiple-equation system

Phillips et al.(1994,1996, Journal of Real Estate Finance and Economics), Ross (2000, Journal of Real Estate Economics), Bajari et. al.(008, National Bureau of Economic Research) etc.

- Isolated modeling processes of the credit underwriting and default leads to biased parameter estimates (**sample selection bias**)

Literature Review

LaCour-Little, Maxam (2001, Journal of Real Estate Finance and Economics), LaCour-Little et al. (2002, Journal of Real Estate Research)

- **Higher predictive power of nonparametric** models (kernel regression) for prepayment and default **comparing with parametric** ones

Stolbov (2012, Journal of NEA), Sternik (2009, Journal of NEA)

- Discussion of **triggers of Russian mortgage crisis 2008-2009**

Strategy of mortgage residential lending development to 2030, Polterovich, Starkov (2007, Economics and Mathematical methods):

- Discussion of the **strategy to develop Russian mortgage market**
- Discussion of the strategy of large-scale mortgage based on the transplantation of modified branch of the savings bank and provided model results for Russian market.

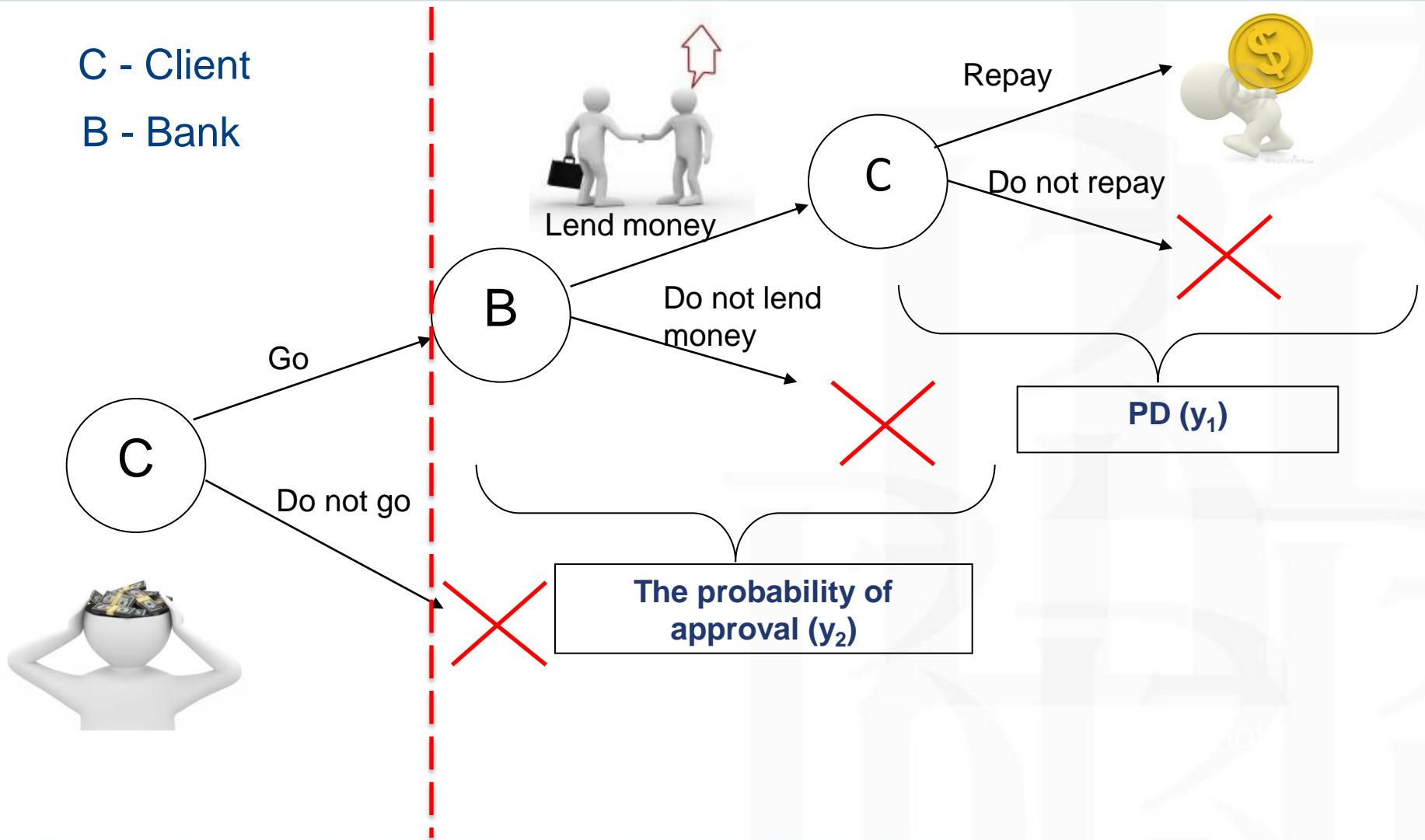
Research Questions

1. What are determinants of mortgage default within an empirical application to the Russian residential mortgage market?
2. Is there difference in results of strictly parameterized and semiparametric models?
3. What is the impact of sample selection bias on the default estimates?

Methodology

C - Client

B - Bank



1) Parametric Approach

- Single-equation model (Probit model)
- Multiple-equation model (Bivariate Probit Model with sample selection correction)

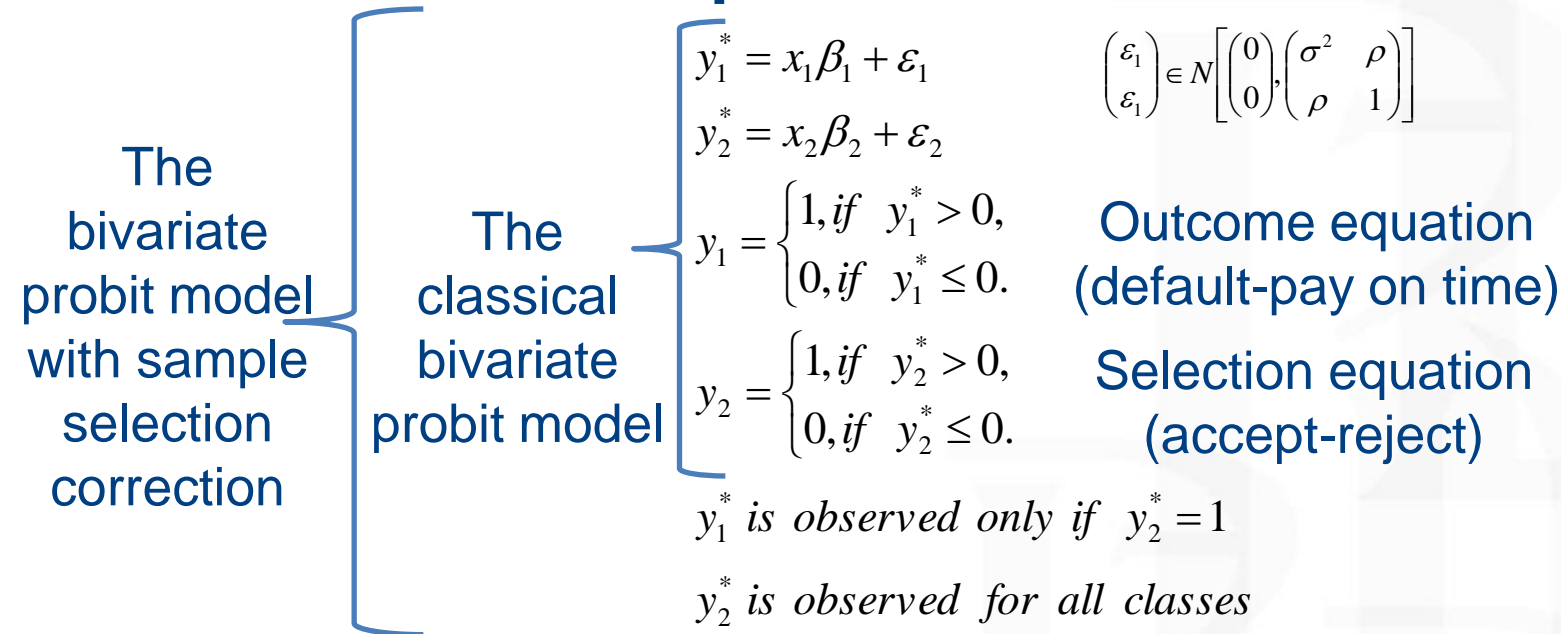
2) Semiparametric Approach

- Multiple-equation model (Local Polynomial Regression with sample selection correction)

Attanasio et al., 2008, International Economic Review, Das, et al., 2003, The Review of Economic Studies

Methodology: Parametric Approach

Bivariate Probit Model with Sample Selection Correction



Heckman's two-stage procedure

$$\hat{\lambda}_i(x_2\hat{\beta}_2) = \frac{\varphi(x_2\hat{\beta}_2)}{\Phi(x_2\hat{\beta}_2)} \quad E(y_1 | y_1 \text{ is observed}) = x_1\hat{\beta}_1 + \hat{\rho}\hat{\sigma}\hat{\lambda}_i(x_2\hat{\beta}_2)$$

Methodology: Semiparametric Approach

$$y_1^* = x_1\beta_1 + g_1(x_1) + \varepsilon_1$$

$$y_2^* = x_2\beta_2 + g_2(x_2) + \varepsilon_2$$

$$y_1 = \begin{cases} 1, & \text{if } y_1^* > 0, \\ 0, & \text{if } y_1^* \leq 0. \end{cases}$$

$$y_2 = \begin{cases} 1, & \text{if } y_2^* > 0, \\ 0, & \text{if } y_2^* \leq 0. \end{cases}$$

y_1^* is observed only if $y_2^* = 1$

y_2^* is observed for all classes

1, 2, 3 polynomials

$$E(y_1 | x_1, y_2^* > 0) = x_1\beta_1 + g_1(x_1) + \lambda_i(\varepsilon_1, \varepsilon_2, \hat{y}_2)$$

Semiparametric rate , LTV*maturity	Linear contract terms
Semiparametric sociodemographic characteristics (cross-products)	Linear sociodemographic characteristics
Semiparametric fitted probability of endorsement	Linear fitted probability of endorsement
Semiparametric unemployment rate, probability of application, unemployment rate*probability of application	Linear macrovariables

Least squares estimation

- 1. Aggregated regional monthly** data on the AHML branch performance, mortgage market characteristics and regional macroeconomic variables for the period from 01/08/2008 to 31/08/2012.
- 2. Loan-level data** from regional AHML branch (4298 applicants): borrower characteristics, terms of the mortgage contract, property characteristics, and the mortgage performance are available.
 - Reject rate=14%
 - Acceptance rate=86%
 - Issued loans 76%
 - Default rate =6% (90 days delinquency)
 - Non defaulted=94%
 - Unissued loans 24%

Variables	Description	Mean	Std. Dev.	Min	Max
Sociodemographic characteristics (4298 applicants)					
Age of borrower	Age of borrower, years	33.99	7.59	21	61
Declared income of main borrower	Monthly income of borrower (in Russian rubles)	30 663.57	26 203.22	1 658.65	38 5531.4
Declared income of co-borrowers	Sum of monthly co-borrowers main income (in Russian rubles)	17 654.25	11 555.85	38.33	72 800.45
Terms of credit contract (2799 contracts)					
Loan limit	Maximum loan limit, Russian rubles	1 087 933	616 643.1	120 000	12 700 000
Loan amount	Loan amount, Russian rubles	1 040 037	573 665.9	120 000	10 000 000
Rate	Contract rate (when fixed), %	11.59	1.64	9.55	19
Maturity	Maturity of credit, months	189.05	62.17	26	360
Downpayment	Downpayment, Russian rubles	854 962.3	706 635.4	40 000	13 820 000
Flat value	Assessed value, Russian rubles	1 894 999	1 049 502	330 000	15 290 000
Monthly payment	Monthly payment, Russian rubles	12 610.96	7 324.47	1 872.44	14 0381
LTV	Loan-to-value ratio	0.56	0.17	0.11	0.94
DTI	Debt-to-income ratio (for declared income)	0.45	0.18	0.06	1
Duration	Total amount of days observed in credit, days	867.22	419.67	18	1 487

Variables	Description	Mean	Std. Dev.	Min	Max
Macrovariables (50 moths)					
Mortgage volume (10.3)		921 777.3	562309.5	116 100	2 191 000
Mortgage amount	Total amount of mortgages in the region	894.40	529.27	134	2112
Mean loan	Average size of mortgage in region, Russian rubles	1 152 568	251 993	899 310	1 908 200
Median maturity	Median maturity for mortgage in region, months	200.79	12.81	173	222.2
Median rate	Median contract rate for mortgage in region, %	12.97	.80	12	14.3
Mean LTV	Average LTV in region	0.58	0.03	0.48	0.65
Mean DTI	Average DTI in region	0.35	0.01	0.33	0.37
Mean m2 value	Average price for 1 square meters in region, Russian rubles	38 622.76	6 165.80	28 782	51 304
Lodging coefficient	Housing price to income ratio, years	3.39	0.71	2.57	4.65
Unemployment rate	Quarterly regional unemployment, %	8.43	1.50	6.3	10.9

Variables	Total (%)
Sociodemographic characteristics (4298 applicants)	
Male	
male	1879 (43.7%)
female	2419 (56.3)
Income of main borrower	
not declared	2918 (67.9%)
0-9999	118 (2.8%)
10000-19999	376 (8.8%)
20000-39999	597 (13.9%)
>=40000	289 (6.7%)
Income of co-borrowers	
not declared	3724 (86.6%)
0-9999	159 (3.7%)
10000-19999	225 (5.2%)
>=20000	190 (4.4%)
Family status	
not declared	46 (1.1%)
single	1220 (28.4%)
married	2358 (54.9%)
widowed	56 (1.3%)
divorced	618 (14.4%)

Variables	Total
Sociodemographic characteristics (4298 applicants)	
Activity category	
not declared	138 (3.2%)
unemployed	1 (0.0%)
soldier	13 (0.3%)
hired employee	3963 (92.2%)
entrepreneur	39 (0.9%)
state employee	144 (3.4%)
Education level	205 (4.8%)
not declared	65 (1.5%)
elementary education	1748 (40.7%)
secondary education	138 (3.2%)
incomplete higher education	2142 (49.8%)
higher education	

Variables	Total
Terms of credit contract (2799 contracts)	
Type of rate	
adjusted	378 (13.5%)
fixed	2421 (86.5%)
Maturity	
<120 moths	181 (6.47%)
120-179	595 (21.26%)
180-239	1 106 (39.51%)
240-299	690 (24.65%)
>=300	227 (8.11%)
LTV	
<0.5	968 (34.58%)
0.5-0.7	1 531 (54.70%)
>=0.7	300 (10.72%)
DTI	2 550 (68.96%)
<0.2	41 (1.11%)
0.2-0.4	505 (13.66%)
0.4-0.6	379 (10.25%)
0.6-0.8	160 (4.33 %)
>=0.8	63 (1.70%)

Empirical Results

Predictive power of mortgage default parametric and semiparametric models are almost the **same**

- right predictions 94.5% and 94.4%

AUC are not statistically different for probit, logit, BVP models, but fitted probability of endorsement is statistically significant in BVP with sample selection correction models

- There is sample selection bias. The **credit underwriting** and **mortgage default** processes should be **modeled jointly**.

PD is higher for male, borrowers with non declared family status or single, state employees.

Empirical Results

PD is higher with higher rate, for loans with maturity less than 15 years, higher loan age.

Not declared income of main borrower is statistically significant in PD. However PD of such borrowers are less than borrowers with small income ($< 10\ 000$).

PD increases when average price for 1 square meters in region increases.

Conclusions

1. Parametric and semiparametric estimations of credit risk have almost the same predictive power.
2. The joint modeling the credit underwriting and mortgage default processes allows to correct for sample selection bias.
3. Obtained results can be used to develop the effective risk management systems in credit organizations.



Thank you
for your attention!

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