

SUPPLEMENTARY MATERIALS

# An Empirical Comparison of Machine-Learning Methods on Bank Client Credit Assessments

Lkhagvadorj Munkhdalai, Tsendsuren Munkhdalai, Oyun-Erdene Namsrai, Jong Yun Lee and Keun Ho Ryu

**Table 1.** Selected variables by TSFFS method and their average random forest importance.

Number	Selected Variables	Description	Average RF importance	Rank
1	LEVRATIO	Ratio of total debt to total assets	11.90	1
2	FIN	Total value of financial assets held by household, 2013 dollars	10.40	2
3	VEHIC	Total value of all vehicles held by household, 2013 dollars	6.89	3
4	AGE	Age of head of household	5.85	4
5	FEARDENIAL	Household feared being denied credit in the past 5 years	5.81	5
6	TPAY	Total value of monthly debt payments, 2013 dollars	5.11	6
7	KGTOTAL	Total unrealized capital gains or losses for the household, 2013 dollars	4.98	7
8	CHECKING	Total value of checking accounts held by household, 2013 dollars	4.67	8
9	WAGEINC	Wage and salary income, 2013 dollars	4.31	9
10	INSTALL	Total value of installment loans held by household, 2013 dollars	4.29	10
11	CONSPAY	total monthly consumer debt payments, 2013 dollars	4.26	11
12	REVPAY	total monthly revolving debt payments, 2013 dollars	4.10	12
13	EDN_INST	Total value of education loans held by household, 2013 dollars	3.91	13
14	LLOAN8	Total balance of household loans where the lender is an other nonfinancial, 2013 dollars	3.71	14
15	SAVING	Total value of savings accounts held by household, 2013 dollars	3.50	15
16	TRANSFOTHINC	Unemployment, alimony/child support, TANF/food stamps/SSI, and other income, 2013 dollars	3.40	16
17	KIDS	Total number of children in household	3.17	17
18	LLOAN4	Total balance of household loans where the lender is finance, loan or leasing company, or inc debt consolidator, 2013 dollars	2.96	18
19	LLOAN7	Total balance of household loans where the lender is an individual, 2013 dollars	2.92	19
20	EQUITINC	ratio of equity to normal income	2.55	20
21	BUSSEFARMINC	Income from business, sole proprietorship, and farm, 2013 dollars	2.33	21
22	EDCL	Education category of head of household	2.16	22
23	WHYNOCKG	Reason household does not have a checking account	2.14	23
24	THRIFT	Total value of account-type pension plans from R and spouse's current job, 2013 dollars	2.13	24
25	BNKRUPLAST5	Household has declared bankruptcy in the past 5 years	2.07	25
26	ILNPAY	Total payment of installment loan, 2013 dollars	2.03	26
27	TURNDOWN	Household has been turned down for credit in the past 5 years	1.99	27
28	LLOAN1	Total balance of household loans where the lender is a commercial bank, 2013 dollars	1.97	28

29	CASHLI	Total cash value of whole life insurance held by household, 2013 dollars	1.82	29
30	KGHOUSE	Unrealized capital gains or losses on the primary residence, 2013 dollars	1.70	30
31	LLOAN11	Total balance of household loans where the lender is a pension, 2013 dollars	1.55	31
32	NBUSVEH	Total number of business vehicles held by household	1.48	32
33	OCCAT1	Occupation categories for head of household	1.36	33
34	SAVBND	Total value of savings bonds held by household, 2013 dollars	1.32	34
35	RACE	Race/ethnicity of respondent	1.28	35
36	SAVED	Indicator of whether the household saved over the past 12 months	1.22	36
37	LLOAN6	Total balance of household loans where the lender is a real estate company, 2013 dollars	1.22	37
38	LLOAN9	Total balance of household loans where the lender is government, 2013 dollars	1.15	38
39	SAVRES3	Reason for saving: family	1.00	39
40	EHCHKG	people w/o checking accounts: ever had an account?	0.99	40
41	OTHNFIN	Total value of other nonfinancial assets held by household, 2013 dollars	0.99	41
42	LOCPAY	Total payment on line of credit, 2013 dollars	0.98	42
43	ORESRE	Total value of other residential real estate held by household, 2013 dollars	0.97	43
44	PAYILN4	payments on fourth installment loan, 2013 dollars	0.93	44
45	EDUNUM	Number of education loan	0.92	45
46	MMDA	money market deposit accounts, 2013 dollars	0.88	46
47	MINBAL	Why no checking account: minimum balance is too high	0.85	47
48	SAVRES5	Reason for saving: purchases	0.84	48
49	ISHOPNONE	Shopping for saving and investments: almost no shopping	0.79	49
50	HHSEX	Gender of household head	0.75	50
51	NSTOCKS	number different companies in which hold stock	0.70	51
52	BFRIENDWORK	Information used for borrowing decisions: friends, material from work/business contacts	0.69	52
53	BMAILADTV	Information used for borrowing decisions: material in mail, tv, radio, advertisements, telemarketer	0.67	53
54	IFRIENDWORK	Information used for investing decisions: friends, material from work/business contacts	0.65	54
55	NOFINRISK	Knowledge of personal finance	0.64	55
56	VLEASE	Total value of leased vehicles held by household, 2013 dollars	0.63	56
57	IDONT	Information used for investing decisions: never borrow	0.59	57
58	IMAGZNEWS	Information used for investing decisions: magazines, newspapers, books	0.58	58
59	SAVRES1	Reason for saving: can't save	0.58	59
60	SAVRES6	Reason for saving: retirement	0.55	60
61	BFINPRO	Information used for borrowing decisions: banker, broker, real estate broker, builder, dealer, insurance agent	0.54	61
62	IFINPRO	Information used for investing decisions: banker, broker, real estate broker, builder, dealer, insurance agent	0.54	62
63	BFINPLAN	Information used for borrowing decisions: lawyer, accountant, financial planner	0.54	63
64	STMUTF	amount in stock mutual funds, 2013 dollars	0.53	64
65	PIR40	Household has a PIR higher than 40%	0.53	65
66	DONTWANT	Why no checking account: does not want/need a checking account	0.53	66
67	TRUSTS	Amount R would receive if they cashed in trusts, 2013 dollars	0.50	67
68	DBPLANCJ	Either head or spouse/partner has a defined benefit pension on a current job	0.49	68

69	PAYMORTO	payments on other loans, 2013 dollars	0.48	69
70	NNRESRE	Total value of net equity in nonresidential real estate held by household, 2013 dollars	0.46	70
71	LLOAN2	Total balance of household loans where the lender is saving and loan, 2013 dollars	0.46	71
72	LLOAN5	Total balance of household loans where the lender is a brokerage and/or life insurance, 2013 dollars	0.45	72
73	COMUTF	amount in combination and other mutual funds, 2013 dollars	0.45	73
74	IFINPLAN	Information used for investing decisions: lawyer, accountant, financial planner	0.45	74
75	PAYVEH4	payments on fourth vehicle, 2013 dollars	0.42	75
76	DONTWRIT	Why no checking account: don't write enough checks to make it worthwhile	0.42	76
77	ISELF	Information used for investing decisions: self, shop around, other personal research	0.42	77
78	PURCH1	First lien on primary residence used for purchase of primary residence	0.41	78
79	MORT2	Amount owed on mortgage 2, 2013 dollars	0.37	79
80	HASSET	Do you have any asset	0.36	80
81	REFIN_EVER	Refinanced first lien mortgage on primary residence	0.35	81
82	NEWCAR2	number of car/truck/SUV with model year no older than one year before the survey	0.34	82
83	NONACTBUS	Value of non-actively managed business(es), 2013 dollars	0.33	83
84	CANTMANG	Why no checking account: can't manage/balance a checking account	0.32	84
85	DONTLIKE	Why no checking account: don't like dealing with banks	0.29	85
86	EOPAY	Total payment of other vehicles, 2013 dollars	0.27	86
87	SVCCHG	Why no checking account: service charges are too high	0.26	87
88	CKMANYSVCS	Why chose main checking account institution: able to obtain many services at one place	0.26	88
89	ANNUIT	Amount R would receive if they cashed in annuities, 2013 dollars	0.25	89
90	BINTERNET	Information used for borrowing decisions: internet/online service	0.25	90
91	TFBMUTF	amount in tax-free bond mutual funds, 2013 dollars	0.22	91
92	NTRAD	number of trades per year	0.20	92
93	OTHER	Why no checking account: other	0.19	93
94	KGINC	Capital gain or loss income, 2013 dollars	0.18	94
95	HCDS	Do you have any certificates of deposit	0.18	95
96	FUTPEN	future pensions (accumulated in an account for the R/S), 2013 dollars	0.16	96
97	CKOTHCHOOSE	Why chose main checking account institution: other reason	0.14	97
98	CKPERSONAL	Why chose main checking account institution: personal relationship	0.08	98
99	MMMF	money market mutual funds, 2013 dollars	0.02	99
100	HCALL	Do you have any call accounts at brokerages	0.00	100
101	OBMUTF	amount in other bond mutual funds, 2013 dollars	0.00	101
102	GBMUTF	amount in government bond mutual funds, 2013 dollars	0.00	102
103	GOVTBND	US government and government agency bonds and bills, 2013 dollars	0.00	103
104	OBND	corporate and foreign bonds , 2013 dollars	0.00	104
105	NOTXBND	tax-exempt bonds (state and local bonds), 2013 dollars	0.00	105
106	MORTBND	mortgage-backed bonds, 2013 dollars	0.00	106

**Table 2.** The selected variables by NAP method.

Number	Selected Variables	Description
1	AGE	Age of head of household
2	BFINPLAN	Information used for borrowing decisions: lawyer, accountant, financial planner
3	EDN_INST	Total value of education loans held by household, 2013 dollars
4	EHPAY	Have any expected payment?
5	HFIN	Have financial assets?
6	HNFIN	Have any nonfinancial assets?
7	HVEHIC	Have vehicles?
8	LEVRATIO	Ratio of total debt to total assets
9	NETWORTH	Total net worth of household, 2013 dollars
10	NLEASE	Number of leased vehicles
11	OTHFIN	Total value of other financial assets, 2013 dollars
12	PAYPEN1	Payments on loan against first pension plan not previously reported, 2013 dollars
13	PLOAN4	Total value of aggregate loan balance by loan purpose: goods and services, 2013 dollars
14	RETQLIQ	Total value of quasi-liquid held by household, 2013 dollars
15	TPAY	Total value of monthly debt payments, 2013 dollars
16	WSAVED	Spent more/same/less than income in past year
17	AGECL	Age of the household head, and categorical variable
18	BNKRUPLAST5	Household has declared bankruptcy in the past 5 years
19	EDUC	Education of the household's head
20	FEARDENIAL	Household feared being denied credit in the past 5 years
21	HHOUSES	Have owned principal residence
22	HODEBT	Have any other debts
23	INCOME	Total amount of income of household, 2013 dollars
24	LIQ	Total value of all types of transactions accounts, 2013 dollars
25	NFIN	Total value of nonfinancial assets held by household, 2013 dollars
26	NWCAT	Net worth percentile groups
27	OWN	Have an owned vehicle
28	PENNUM	Number of pension plan not previously reported
29	PLOAN6	Total value of aggregate loan balance by loan purpose: education and professional expenses, 2013 dollars
30	REVPAY	Total monthly revolving debt payments, 2013 dollars
31	TURNDOWN	Household has been turned down for credit in the past 5 years
32	ANYPEN	Pension exists for either head of household or spouse
33	CONSPAY	Total monthly consumer debt payments, 2013 dollars
34	EDUNUM	Number of education loan
35	FIN	Total value of financial assets held by household, 2013 dollars
36	HINSTALL	Have Installment loan
37	HOMEEQ	Total value of equity in primary residence of household, 2013 dollars
38	INCPCTLECAT	Alternate income percentile groups
39	LLOAN10	Total balance of household loans where the lender is a store and/or a credit card, 2013 dollars

40	NHNFIN	Total nonfinancial assets excluding principal residences, 2013 dollars
41	NWPCTLECAT	Alternate net worth percentile groups
42	PAYEDU3	Payments on third education loan, 2013 dollars
43	PIRCONS	Ratio of monthly non-mortgage non-revolving consumer debt payments to monthly income
44	PURCH1	First lien on primary residence used for purchase of primary residence
45	SAVED	Indicator of whether the household saved over the past 12 months
46	TURNFEAR	Household has been turned down for credit or feared being denied credit in the past 5 years
47	ASSET	Total value of assets held by household, 2013 dollars
48	DCPLANCJ	Either head or spouse/partner has any type of account-based plan on a current job
49	EDUPAY	Total payment of education loan
50	HCHECK	Have checking account
51	HLIQ	Household has any checking, savings, money market or call accounts
52	HOUSECL	Home-ownership category of household
53	INSTUTION	Total balance of household loans from the lending institutions
54	LLOAN7	Total balance of household loans where the lender is an individual, 2013 dollars
55	NINC2CAT	Income percentile groups
56	ODEBT	Total value of other debts held by household, 2013 dollars
57	PAYILN3	Payments on third installment loan, 2013 dollars
58	PIRMORT	Ratio of monthly mortgage payments to monthly income
59	PURPOSE	Loan purpose
60	SAVRES3	Reason for saving: family
61	VEHIC	Total value of all vehicles held by household, 2013 dollars
62	ASSETCAT	Asset percentile groups
63	DEBT2INC	Ratio of total debt to total income
64	EHCHKG	People w/o checking accounts: ever had an account?
65	HEDN_INST	Installment loans not classified elsewhere
66	HMRTHEL	Have principal residence debt
67	HOUSES	Total value of primary residence of household, 2013 dollars
68	INTDIVINC	Interest (taxable and nontaxable) and dividend income, 2013 dollars
69	LLOAN8	Total balance of household loans where the lender is an other nonfinancial, 2013 dollars
70	NINCCAT	Normal income percentile groups
71	OTH_INST	Total value of other installment loans held by household, 2013 dollars
72	PAYORE2	Payments on second other residential property, 2013 dollars
73	PLOAN2	Total value of aggregate loan balance by loan purpose: home improvement, 2013 dollars
74	RESDBT	Total value of debt for other residential property held by households, 2013 dollars
75	SAVRES4	Reason for saving: home
76	WHYNOCKG	Reason household does not have a checking account

---