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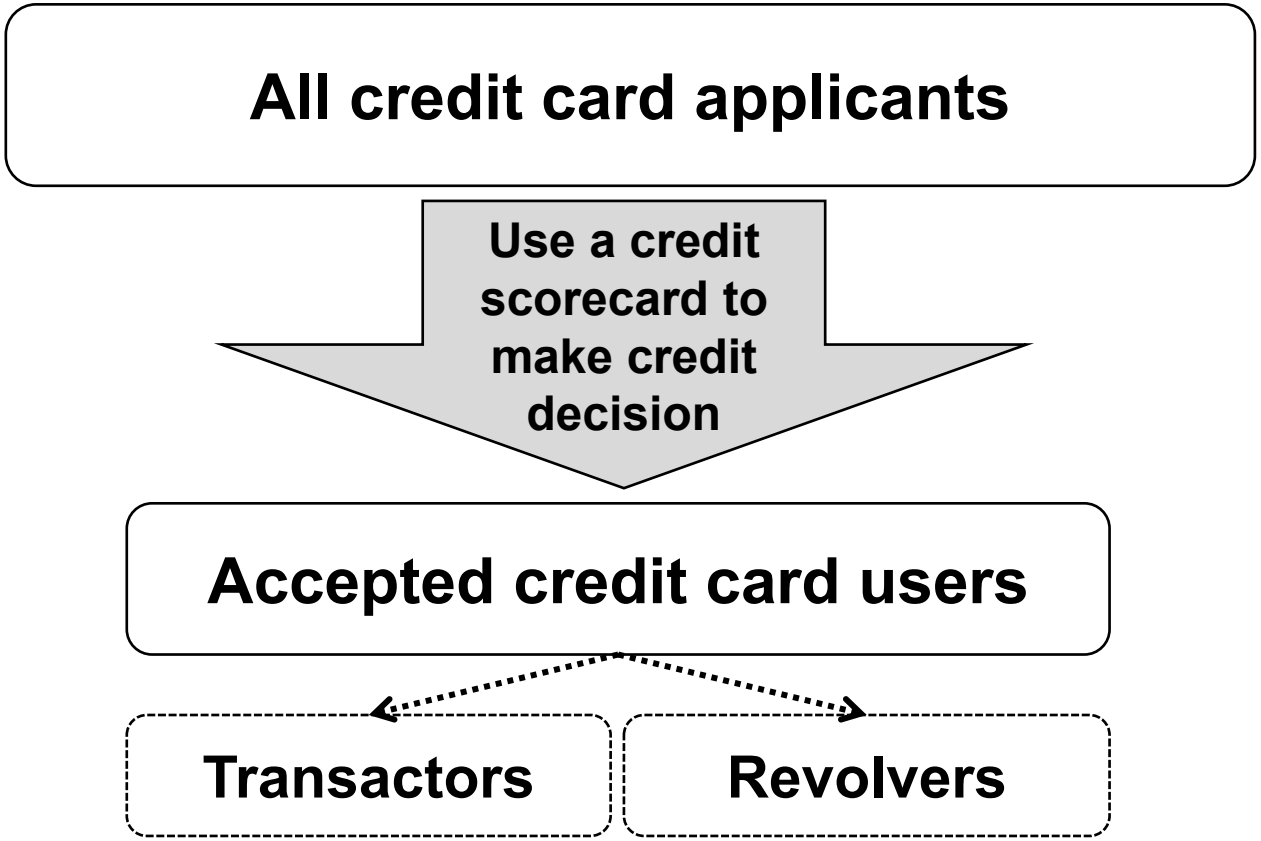
Using a Transactor/Revolver Scorecard to Make Credit and Pricing Decisions

Mee Chi So Lyn Thomas
University of Southampton

Hsin-Vonn Seow
University of Nottingham Malaysia Campus

The Standard Approach



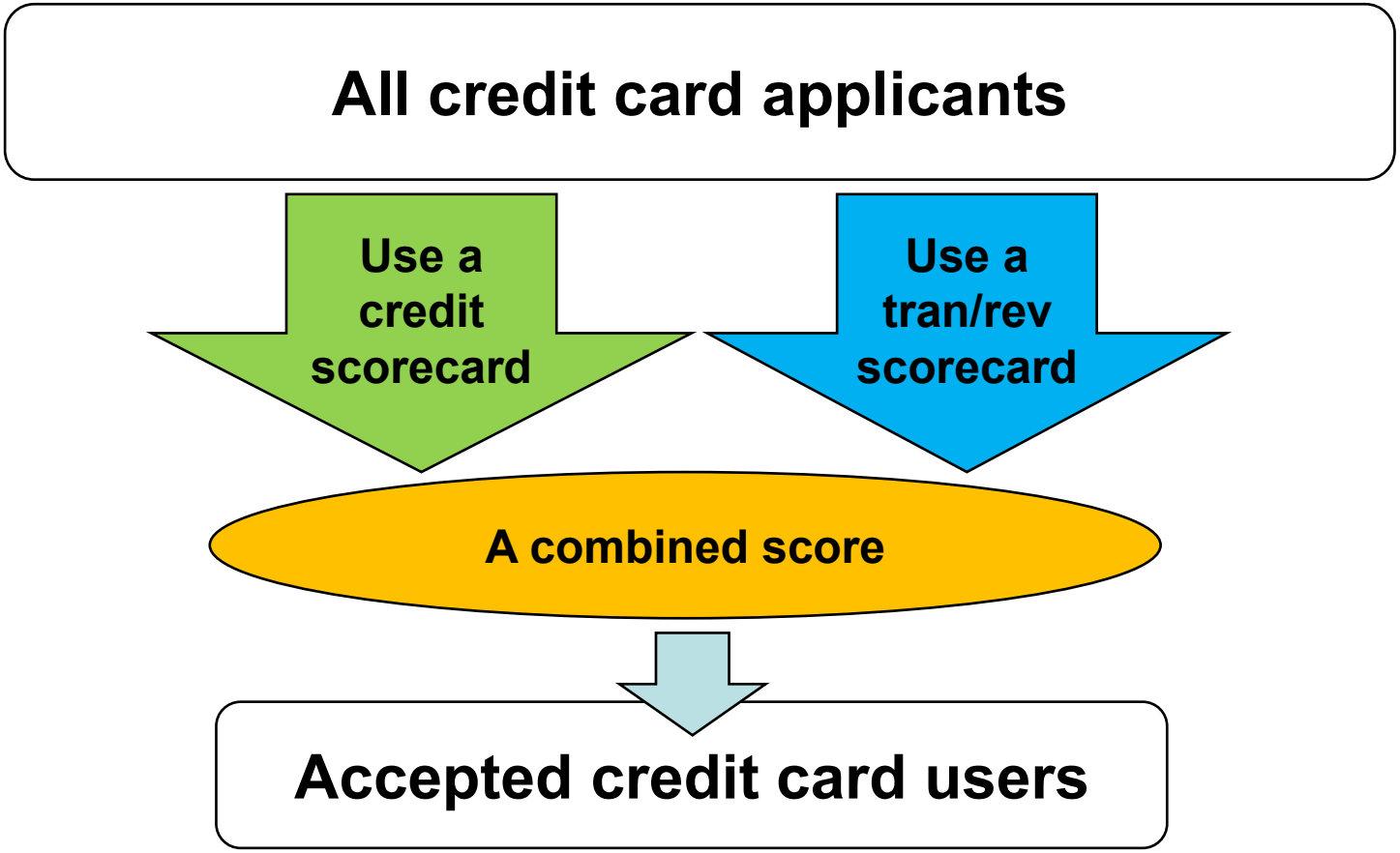
Transactors and Revolvers

Transactors
- all are Goods
- profit from merchant service charge only

Revolvers
- higher chance to be Bads
- main profit from interest on the balance

- Important in terms of default risk
- More important in terms of profitability
- Could we estimate this when making credit decision?

Our Proposed Approach



A Combined Score

Define: T-Transactor, R-Revolver, G-Good, B-Bad

A score gives the probability the new customer is likely to be Good:

$$P(G|\boldsymbol{x}) = P(T|\boldsymbol{x})P(G|\boldsymbol{x},T) + P(R|\boldsymbol{x})P(G|\boldsymbol{x},R)$$

Since no Transactor can default, $P(G|\boldsymbol{x},T)$=1.

Therefore,

$$P(G|\boldsymbol{x}) = P(T|\boldsymbol{x}) + P(R|\boldsymbol{x})P(G|\boldsymbol{x},R)$$

To Develop The Two Scorecards

The Tran/Rev Scorecard

- Using all data

$$s_t(\boldsymbol{x}) = ln\left(\frac{P(T|\boldsymbol{x})}{P(R|\boldsymbol{x})}\right) \Rightarrow P(T|\boldsymbol{x}) = \frac{1}{1+e^{-s_t(x)}}\ ,\ P(R|\boldsymbol{x}) = \frac{1}{1+e^{s_t(x)}}$$

The Good/Bad Scorecard to Revolvers Only

- Using revolvers' data only

$$s_R(\boldsymbol{x}) = ln\left(\frac{P(G|\boldsymbol{x},R)}{P(B|\boldsymbol{x},R)}\right) \Rightarrow P(G|\boldsymbol{x},R) = \frac{1}{1+e^{-s_R(x)}},$$

$$P(B|\boldsymbol{x},R) = \frac{1}{1+e^{s_R(\boldsymbol{x})}}$$

A Numeric Example

- Credit card data from a Hong Kong bank
- Accounts opened 2002-2005; Outcome period: 2006
- Total 6,308 accounts: 1,577 Bad, 4,731 Good
- List of variables: Occupation, Education type, Citizenship, Residential type, Employment status, Annual income, Months with bank and Age
- Use weight-of-evidence for all characteristics
- Use stepwise logistic regression
- Use ten-fold cross validation

	Good	**Bad**	**Total**
Transactor(count and column %)	2958 (63%)	0 (0%)	2958 (47%)
Revolver(count and column %)	1773 (37%)	1577 (100%)	3350 (53%)
Total(count)	4731	1577	6308

Coefficients for All Scorecards

Variable (WoE)	Standard Scorecard (Event=Good)		Transactor/Revolver Scorecard (Event=Transactor)		Good/Bad Scorecard (by Revolvers only) (Event=Good)	
	Coefficient (Mean)	Coefficient (S.D.)	Coefficient (Mean)	Coefficient (S.D.)	Coefficient (Mean)	Coefficient (S.D.)
Intercept	1.3929***	0.0072	-0.1254**	0.0053	0.4291***	0.0125
Occupation	0.7796***	0.0292	0.5994***	0.0209	0.5287***	0.0328
Education type	1.3961***	0.0678	0.4701**	0.0556	1.4056***	0.0745
Citizenship	1.2286***	0.0743	0.9286***	0.0255	0.8748**	0.0850
Residential type	1.1147***	0.0578	0.6864***	0.0391	0.7486***	0.0707
Employment status	0.1146**#	0.1848	0.3951**	0.0430	-	-
Months with bank	1.1741***	0.0187	0.7998***	0.0209	0.8240***	0.0259
Annual income	-	-	0.2150**	0.0290	-	-
Age	-	-	0.2660**	0.0291	-	-

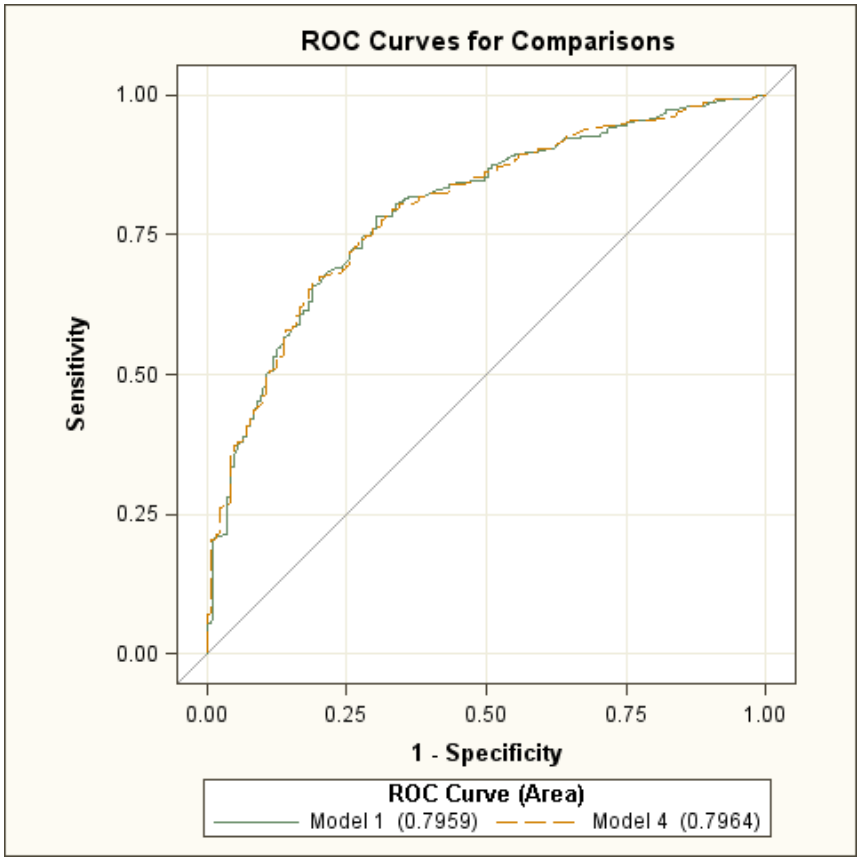
*** significant at 0.0001; ** significant at 0.05;
#selected by three models only. For models do not pick up the variable, we assume the coefficients equal 0.

Gini Coefficients

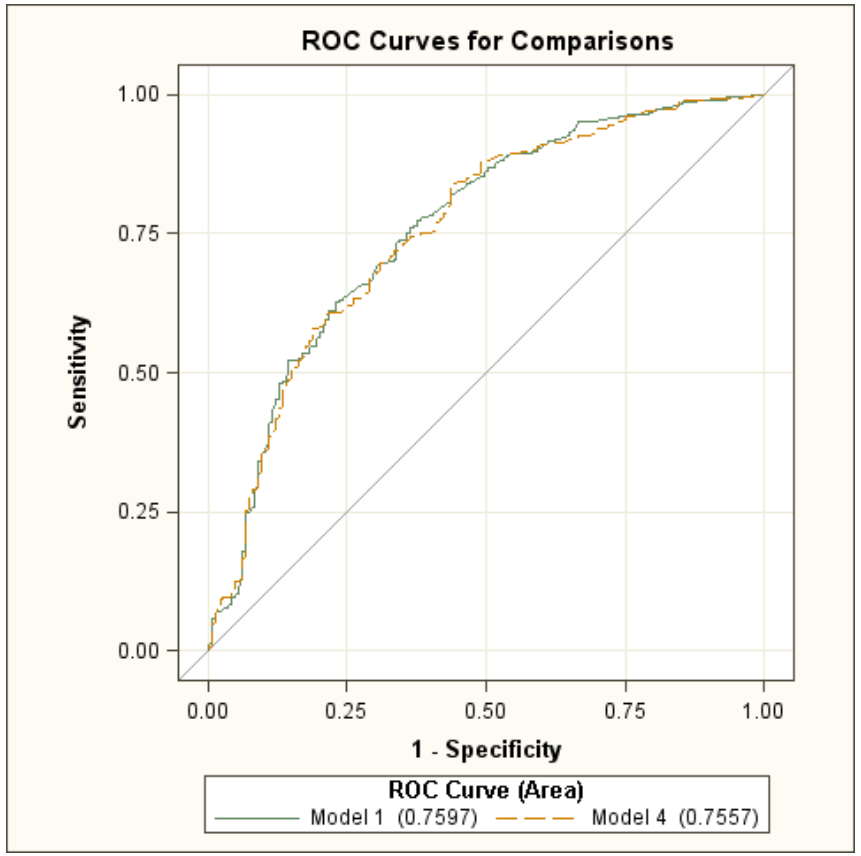
	Gini coefficients for different scorecards				ROC Contrast Test Results between Standard and Combined
	Standard	Tran/Rev	G/B with Rev only	Combined	
Validation 1	0.592	0.45	0.596	0.592	0.039(0.8434)
Validation 2	0.47	0.394	0.47	0.474	0.5008(0.4791)
Validation 3	0.556	0.45	0.542	0.558	0.0488(0.8251)
Validation 4	0.52	0.42	0.518	0.511	2.1165(0.1457)
Validation 5	0.482	0.426	0.486	0.48	0.0789(0.7788)
Validation 6	0.526	0.4	0.53	0.53	0.3427(0.5583)
Validation 7	0.512	0.428	0.506	0.508	0.9092(0.3403)
Validation 8	0.524	0.44	0.522	0.532	0.057(0.8114)
Validation 9	0.548	0.432	0.54	0.542	0.8449(0.358)
Validation 10	0.484	0.47	0.48	0.49	1.2506(0.2634)
Average	**0.522**	**0.431**	**0.519**	**0.522**	

ROC Curves for Two Folds

Validation 1

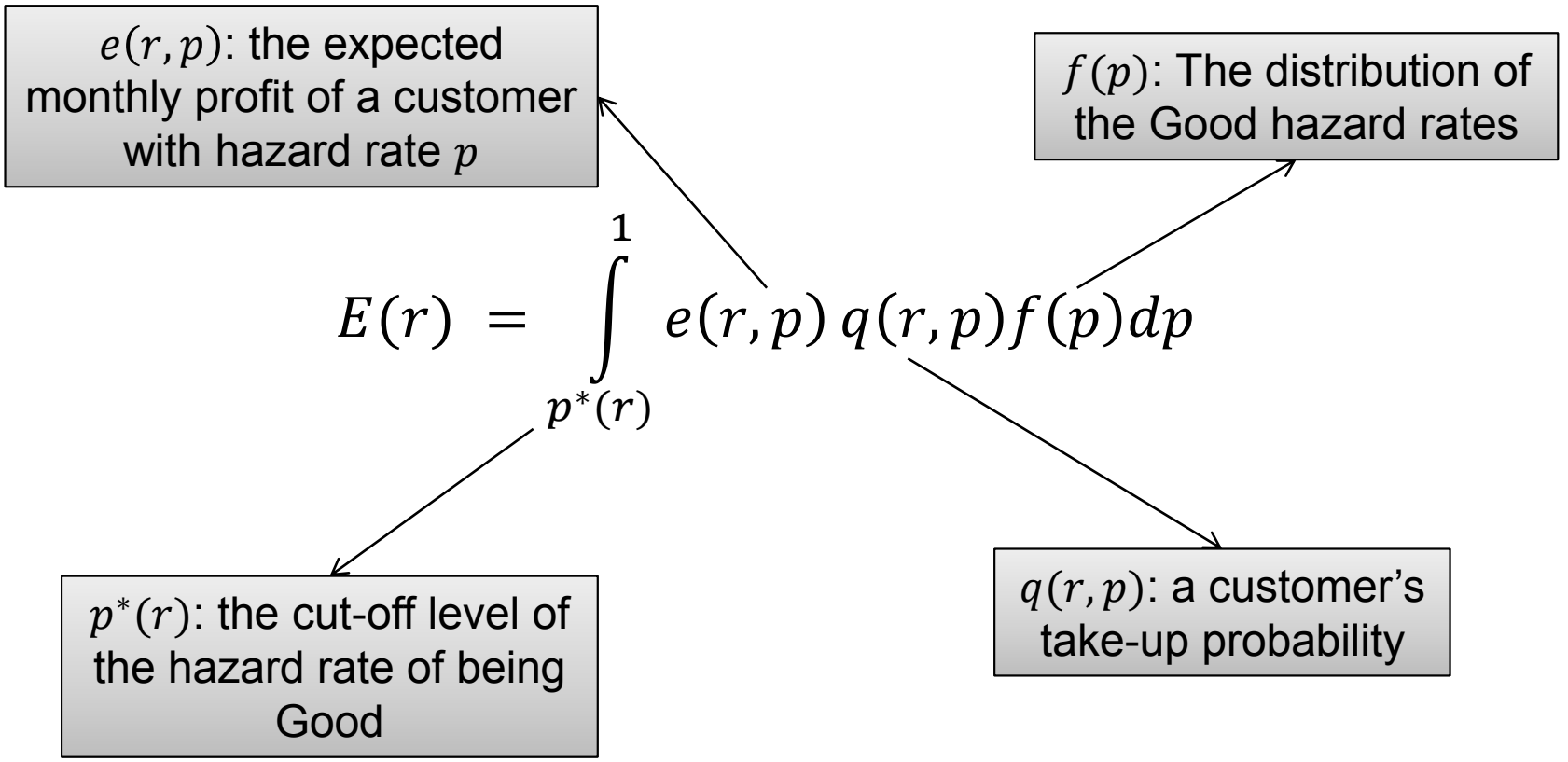


Validation 4



Credit Card Profitability Model

If the interest rate offered on credit cards is r, the corresponding expected monthly profit for the lender is:



Risk and Take Function

- Population's hazard risk distribution

$$F(p) = \begin{cases} 0, p < 0.5 \\ 2p^2 - 2p + 0.5, 0.5 \leq p < 1 \\ 1, p = 1 \end{cases}$$

- Take Function (Phillips, 2005; Thomas, 2009)

$$q(r, p) = Max\{0, 3 - 10r - 2p\}$$

  - For example, if interest rate $r = 3\%$ and the hazard rate is 0.9, the take rate is

$$q(3\%, 0.9) = 3 - 10(3\%) - 2(0.9) = 90\%$$

The Expected Profit: $e(r, p)$

- Income – interchange fees and interest on balance
- The expected profit:

$$e(r,p) = Interchange\ fee - \ Average\ Purchase$$
$$+P(Not\ Default\ in\ N\ period) \times (Repayment\ in\ N\ period)$$
$$+P(Default\ in\ N\ period) \times (Recovery\ via\ Collection)$$

- Given an interest rate, find the optimal cut-off probability by

$$e(r,p^*) = 0 \Rightarrow\ p^* = \left(\frac{(1-m)(1+r_F)^N}{l_D(1+r)^{N-1}} + \frac{l_D - 1}{l_D}\right)^{1/N}$$

Parameters required

m : Interchange rate

r : Interest per period of the credit cards

r_F : Interest rate at which lenders can borrow money per period

l_D : Loss given default (LGD)

N : Average number of periods before repaying the average purchase

To Estimate N

N: average number of periods before a purchase is paid off

B: average balance carried over per period per customer

P: average amount purchased per period per customer

C: average repayment amount per period per customer

Interest paid + Ave. Expenditure = Ave. Repayment,

i.e.

$$rB + P = C \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (*)$$

To Estimate N (cont.)

- Assume the user pays off the costs in the order they are incurred

$$(1+r)B + P = CN \ldots\ldots\ldots\ldots\ldots\ldots\ldots (**)$$

- Using (*) and (**),

$$B = \frac{C - P}{r}$$

$$N = \frac{(1+r)B + P}{C} = \frac{B + C}{C}$$

A Numerical Example

m	Interchange rate	2%
r_F	Interest rate at which lender can borrow money per period	1%
l_D	LGD	60%
P	Average purchase per period	51
C	Average repayment per period	60

Using the above parameters and the equations listed before, we can find the expected profit and the corresponding hazard rate:

r	p^*	$(p^*)^{12}$	$E(r)$
3%	0.969	0.687	2.084
2%	0.983	0.817	1.783
4%	0.957	0.590	2.040

With a Tran/Rev Scorecard

If the interest rate offered on credit cards is r, the corresponding expected monthly profit for the lender is:

$$E(r) = \int_{-\infty}^{\infty} dt \int_{p_R^*(t)}^{1} e(r,p)\, q(r,p) f(p,t) dp$$

Risk and Take Function

- Same take function

$$q(r,p) = Max\{0, 3 - 10r - 2p\}$$

- Population's hazard risk distribution

$$F(p,t) = \begin{cases} 0 & p < 0.5 \\ 2p^2 - 2p + 0.5 & 0.5 \le p < 1, 2p - 1 > t \\ 2tp - t - 0.5t^2 & 0.5 \le p < 1, 2p - 1 \le t \\ 1 & p = 1, t = 1 \end{cases}$$

Percentage of transactors

$$\bar{t} = \int_0^1 t dt \int_0^1 f(p,t)\, dp = 2/3$$

The Expected Profit: $e(p_R, t)$

- t: the transactor score
- p_R: the Good hazard rate from the Revolver Good/Bad scorecard
- $e(p_R, t) = t \times (Interchange\ fee)$

$$+(1-t)[Interchange\ fee - Average\ Purchase$$

$$+ P(Not\ Default\ in\ N\ period) \times (Repayment\ in\ N\ period)$$

$$+P(Default\ in\ N\ period) \times (Recovery\ via\ Collection)]$$

- Given an interest rate, find the optimal cut-off probability by

$$e(p_R^*, t) = 0$$

$$\Rightarrow p_R^* = \left(\frac{(1+r_F)}{l_D(1+r)^{N_R-1}}\left(\frac{tP_T}{(1-t)P_T}\left(1-m-\frac{1}{1+r_F}\right)+1-m\right)+\frac{l_D-1}{l_D}\right)^{1/N_R}$$

With a Tran/Rev Scorecard

N: average number of periods before a purchase is paid off
B: average balance carried over per period per customer
P: average amount purchased per period per customer
C: average repayment amount per period per customer

Revolvers

$$rB_R + P_R = C_R$$
$$(1+r)B_R + P_R = C_R N_R$$

Transactors

$$B_T = 0$$
$$C_T = P_T \Rightarrow N_T = 1$$

All users

$$\mathrm{P} = P(T)P_T + \big(1 - P(T)\big)P_R,$$
$$C = P(T)C_T + \big(1 - P(T)\big)C_R,$$
$$B = \big(1 - P(T)\big)B_R,$$

$N = \alpha N_R + (1-\alpha)$ where $\alpha = \frac{C_R(1-P(T))}{C_T P(T) + C_R(1-P(T))}$

The Numerical Example with Tran/Rev Split

P	Average purchase per period	51
C	Average repayment per period	60
$P(T)$	Percentage of transactors	2/3

P_T	P for Transactor	72
C_T	C for Transactor	72
P_R	P for Revolver	9
C_R	C for Revolver	36

$p_R^*(t)$: the optimal cut-off corresponding to transactor score t

r	t											E(r)
	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	
3%	0.960	0.959	0.957	0.956	0.953	0.950	0.943	0.929	0.839	0.000	0.000	0.330
4%	0.924	0.922	0.919	0.915	0.909	0.898	0.872	0.000	0.000	0.000	0.000	0.399
2%	0.982	0.981	0.980	0.979	0.977	0.975	0.971	0.963	0.940	0.000	0.000	0.311

Conclusion & Possible Extensions

- Build a scorecard to estimate $P(T|x)$
- How to use the score in profitability modelling
- The model with Tran/Rev: acknowledge the profitability of Transactors so that the estimation on profitability is more accurate and offer a different price
- Use it for Churn prediction?

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Thank you