Pricing for Risk

Mark Somers

Agenda

Price of a loan needs to compensate for risks taken and the time value of money. The key risks typically considered include:

- Credit: The risk that accounts default and that loss rates vary through the economic cycle
- Interest Rate: The risk that the cost of funds change
- Liquidity: The risk that loan repayment/drawdown requires funding at unexpected points

For consumer loans the credit risks tend to dominate with the other components being absorbed in a flat "cost of funds". In this talk I will look to:

Describe a typical loan pricing problem

The pricing Optimisation problem and reasons why it is hard to solve

Some approaches to solving the problems encountered

Market position and regulatory impact:
Non Bank, Standardised and IRB

Structure of a Pricing Optimisation Problem

Typically a lender will want to achieve maximum NPV per unit capital over a time horizon constrained by:

- Achieving a hurdle Marginal Return on Capital (e.g. RAROC): Typical of most banks - capital can be raised/re-allocated if the marginal return on capital of a business exceeds a desired hurdle
- Capital Consumed: Relevant in situations where capital is fixed - in this case maximising compound rate of return for the capital available becomes the target
- Funding: This is typically the case for Peer to Peer or Securitised lenders where they are not holding the risk on their balance sheet. Typically they are incentivised to achieve a hurdle return on funds and maximise lending at or above this level
- Risk Appetite (e.g. exposure concentration limits, specialist lenders): In this case constrained by market size of a niche product

Typically Return on Capital is the dominant constraint. But timing of losses is important - tranche, marginal and portfolio.

$\tau_{capital} \sim {}^{1}/_{r_{equity}} \sim 10\ years$ Time horizon for return on equity for banks is often similar to a typical economic cycle → Averaging performance metric is challenging as depends on which bits of the cycle are included

FCA 6-Tests for unfair discriminatory pricing

FCA price discrimination definition:
"firms charging different prices to different consumers based on differences in consumers' price sensitivity" – it is not necessarily unfair

Test	Less Concern	Greater Concern
Who is discriminated against?	Wealthy	Poor
How much is the harm?	Profit difference is low and immaterial to the harmer segment	Significantly more profit from some segments
How many?	Few	Many
Is it transparent and controllable by the consumer?	Clear and controllable	Opaque and based on fixed characteristics
Is the product essential?	Discretionary	Essential
Would society view the price sensitivity as egregious	Little concern	Wide publicity of the unfairness

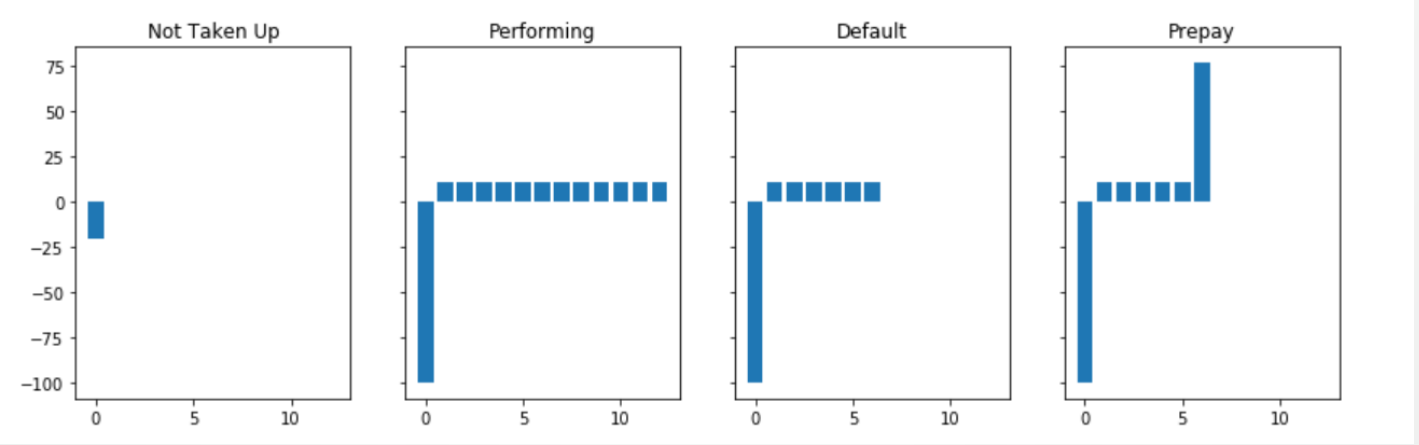
July 2019 published 3 Policy statements (Overdrafts, Buy now pay later and Rent to Own) to regulate unfair pricing in these markets. Follows the High Cost Credit rules already implemented.
In addition published a Feedback Statement on their view on discriminatory pricing in general

General Concepts

Efficient credit pricing of even a simple repayment loan is a complex constrained optimisation problem requiring (among others) an understanding of:

- Probability and timing of default (split by risk grade)
- Probability and timing of prepayment (internal/external - split by risk grade)
- Elasticity of demand (applying for loan) at different price points (segmented?)
- Probability of drawing down the loan at different price points
- Fixed and Marginal costs (e.g. of acquisition, funds, capital, servicing etc)
- Changes in any of the above, but particularly default rate over time

The objective is broadly to maximise the Net Present Value of probability weighted cash flows as some ratio of capital consumed.



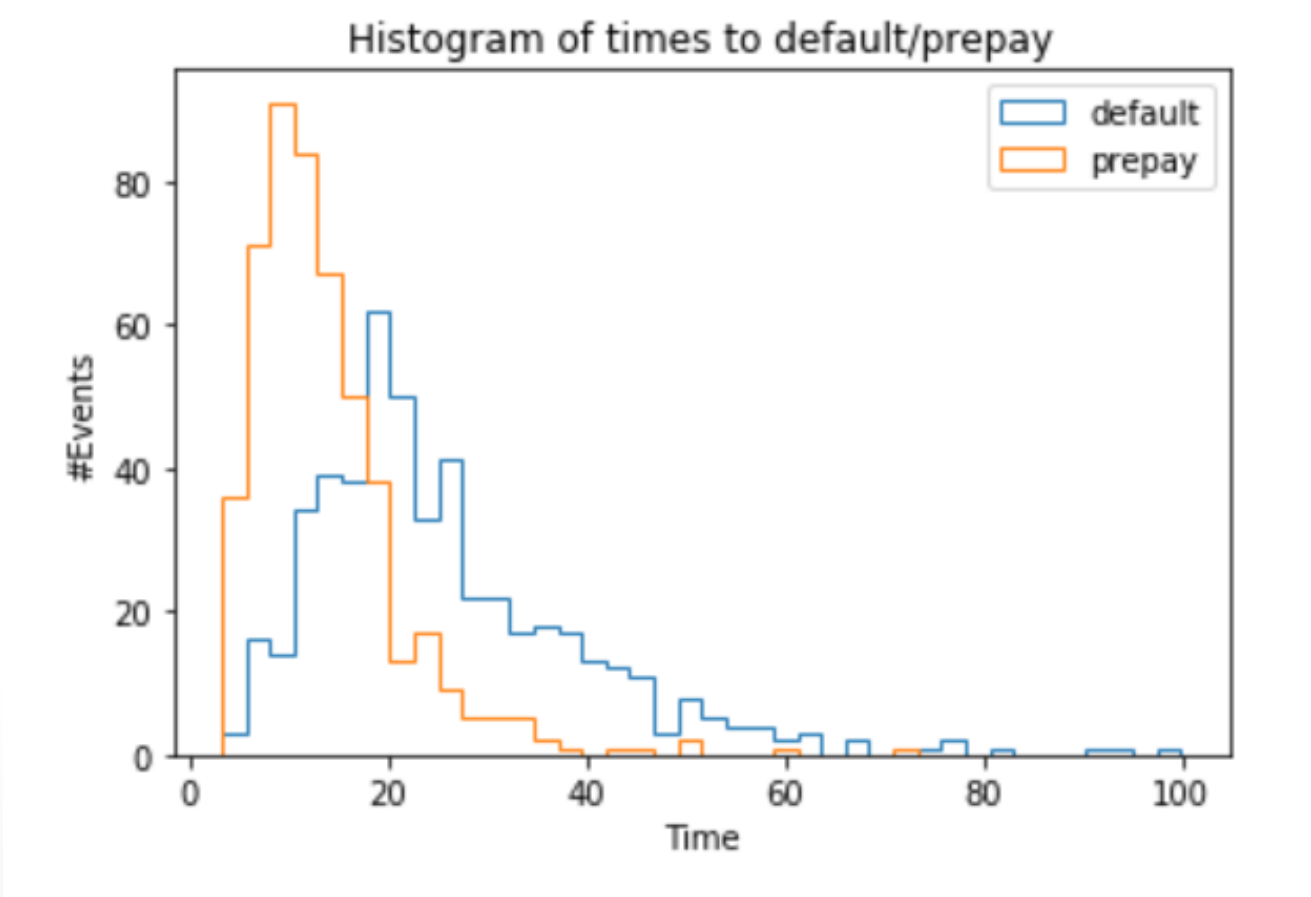
Typical Cash Flows under possible outcomes

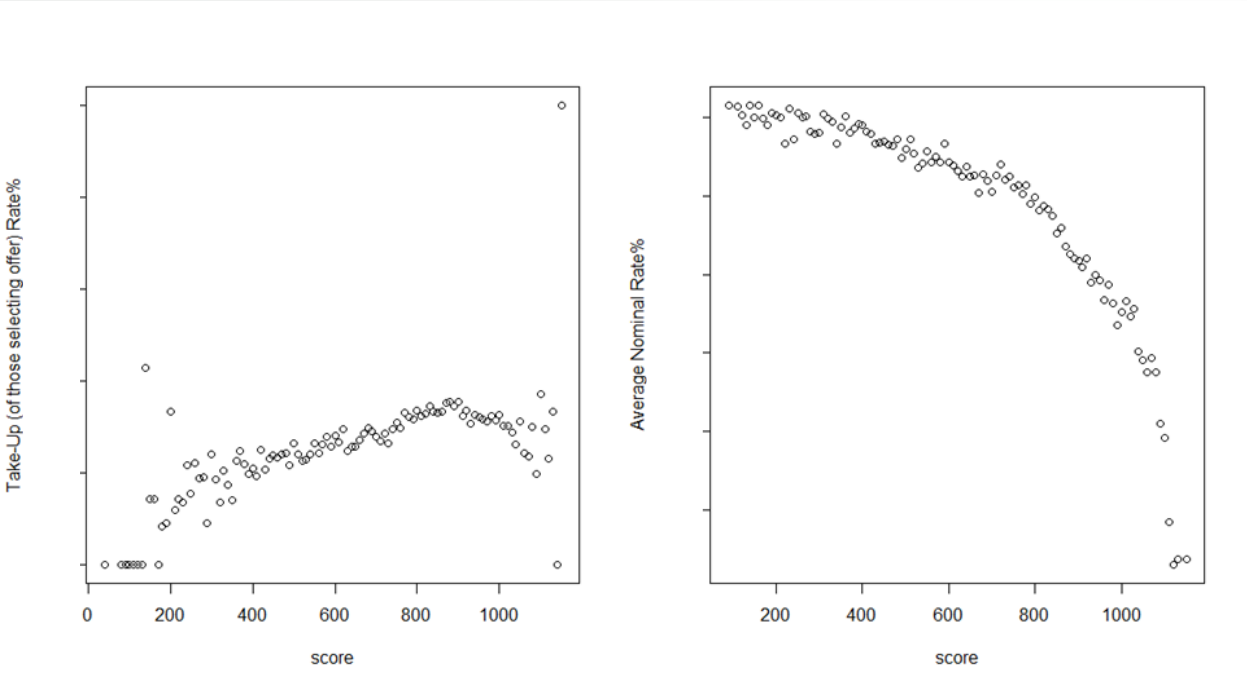
NPV: $= \sum \frac{CF_i}{(1+r)^i}$

IRR: $\sum \frac{CF_i}{(1+r)^i} = 0; r = IRR$

Modelling of Cash Flows

- Timing of default and prepayment is critical, it can be modelled using discrete time Survival Analysis to achieve this. Model forecasts probability of default in time t+1 given not default at time t.
- In addition to maturity (t) will also want to consider pricing segmentation drivers (risk band, Term, new/refinance etc).
- Prepayment is often driven by cross selling refinance loans vs external refinance. These are typically modelled separately as the former can be controlled / managed by changing marketing activity etc.





- Demand elasticity (probability of applying for a loan) & take-up (probability of drawing down the loan) are affected by loan price and terms.

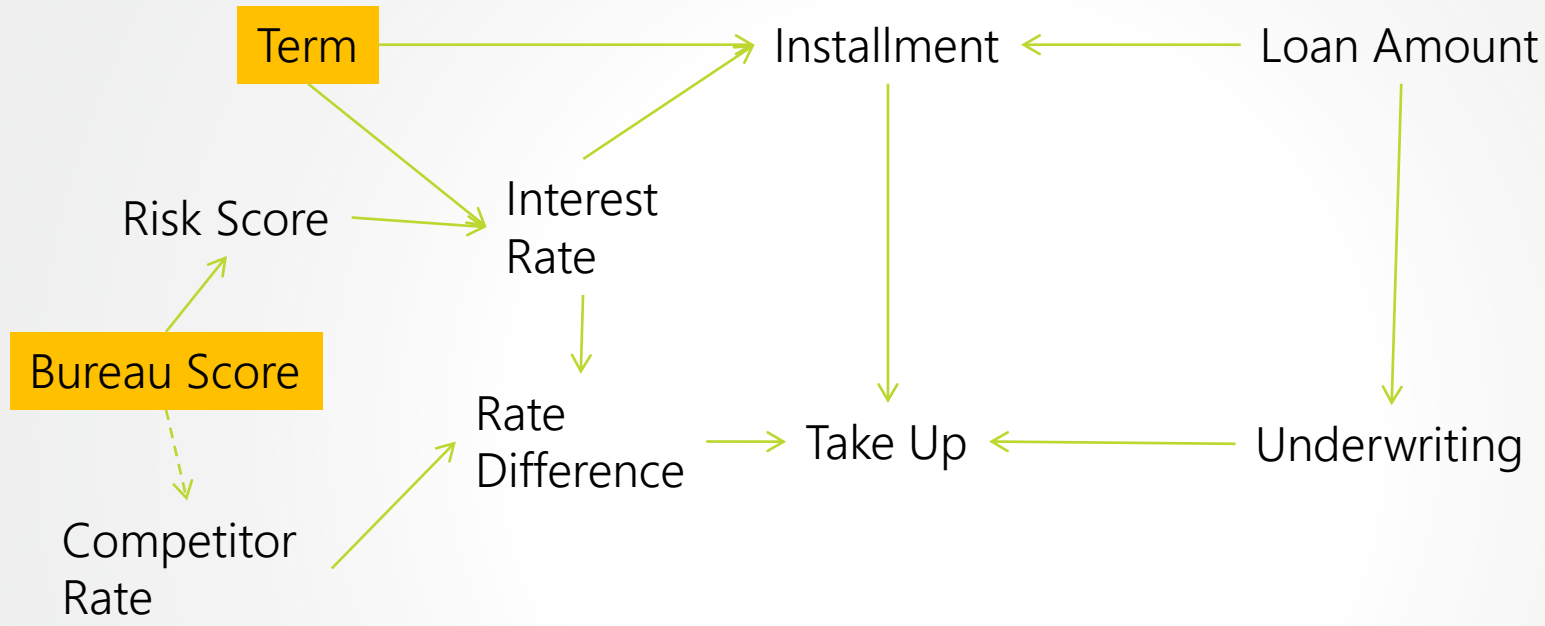
  → Historic behaviour will be biased by past pricing strategy

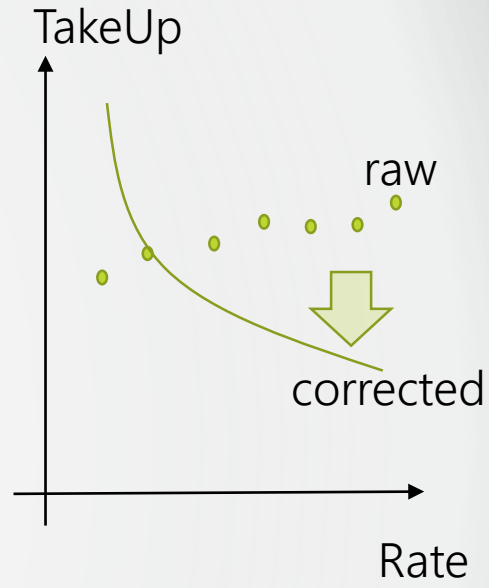
  → Increasing price will drive lower risk customers to not take up preferentially so creating adverse selection bias

- Techniques for modelling causal effect of price has been covered before at previous conferences – briefly…
  - Do random A v B trials
  - Rely on abrupt pricing changes over time to distinguish sensitivity
  - Use a model to control for previous strategy and reveal underlying sensitivity

Modelling Demand Elasticity and Take-Up

A typical causal graph





We want to know the causal effect of Interest Rate on Take-up.

- 2 paths, via headline rate difference vs competitors and size of monthly instalment.

- Just need to control for Term and Bureau Score, remaining sensitivity is causal

Controlling for these factors reverses the observed sensitivity identified previously

NB We don't need to know competitors pricing just what could be the common information

Why is pricing optimisation is hard

Optimisation search space can be large and difficult to solve robustly

- Global vs Segment level optimisation? Is there cannibalisation between terms and loan amount segments
- Typical optimisation may have c 100 price segments – risk x term x refi x channel x loan amount
- Multiple overlapping portfolio constraints (concentration limits, overall funding, overall impairment charge, advertised APRs)

Component estimates cannot be accurately estimated due to limited and biased data

- Estimates of default and prepayment hazard have statistical errors – these can become material if some term x risk combinations are not well populated historically
- Estimates of elasticity and take-up are typically confounded. Depending on the efficiency of historical experimentation, may not be well defined (particularly at a granular level)
- Take-Up probability creates selection effect to higher risk

Components vary stochastically over time

- Default rates very over the economic cycle
- Prepayment rates are sensitive to changes in interest rate and competitor position
- Elasticity is dependent on competitor strategy over time
- Take up will depend on competitor rates and economic perceptions

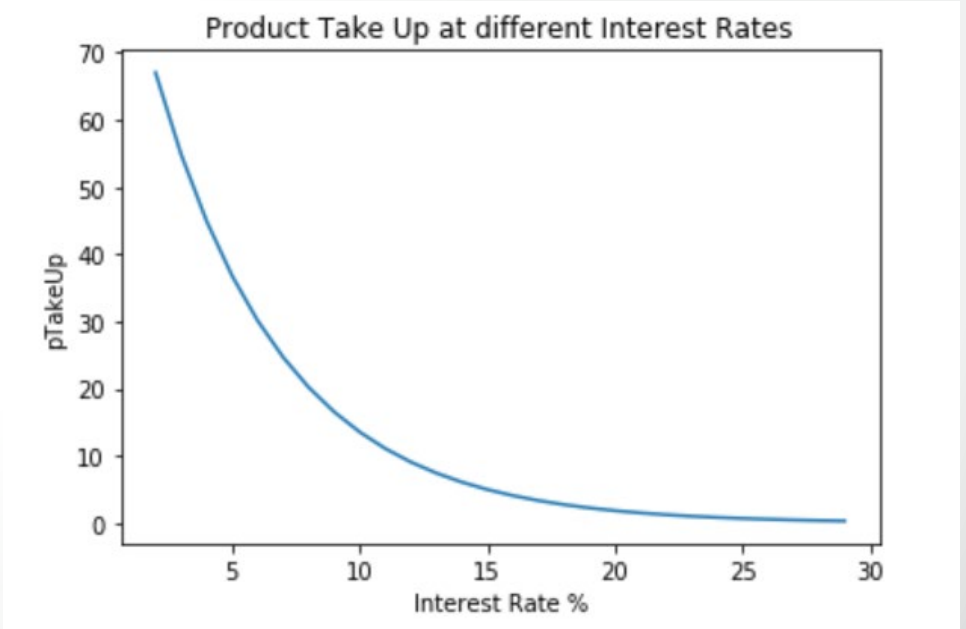
A Simplified Example

Consider a simple fixed term loan which has a single repayment (no opportunity for prepayment) and costs are immaterial. The profitability of the loan could be expressed as:

$$Profit = h(r).(r(1-p)-p)$$

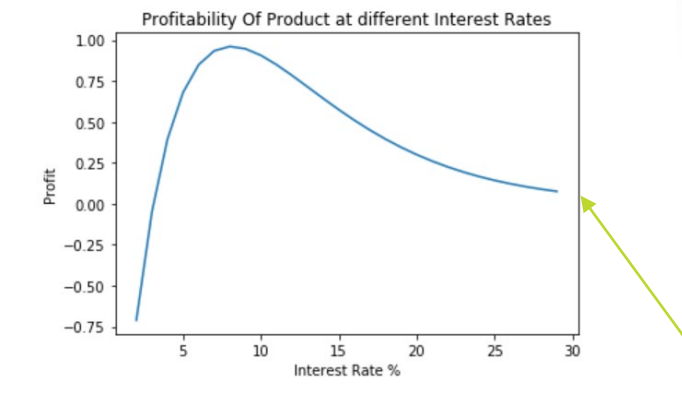
Where: h = Probability of Take up
r = Interest Rate less cost of funds
p = Probability of Default

Profit function is non-linear in r, linear in p
Assume t is known accurately
Assume no adverse selection bias (p independent r)
Assume p is uncertain between 1% and 10%

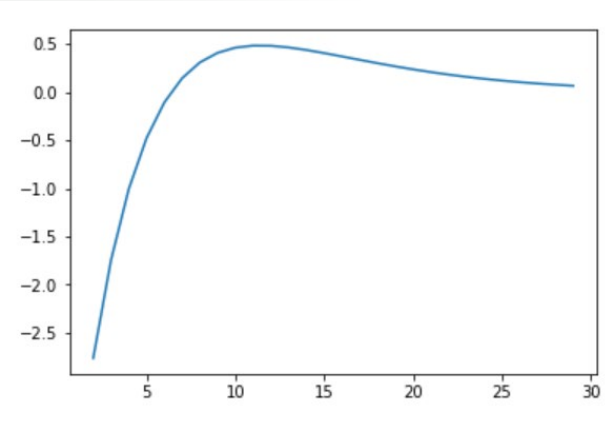


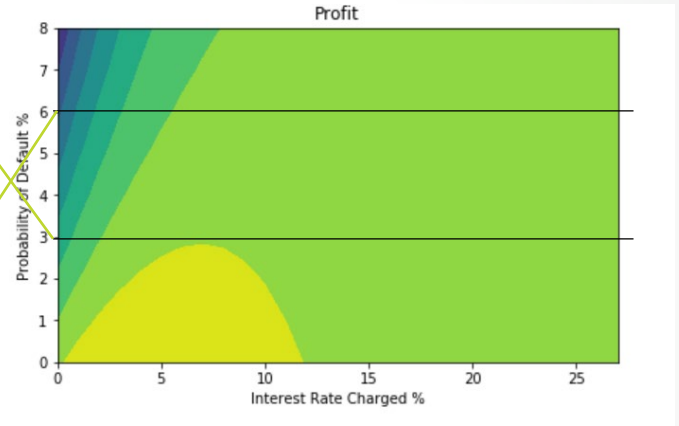
Optimal Price under uncertainty

Default rate is 3%
Optimal price: 8%



Default rate is 6%
Optimal price: 11%
Profit @8% ~0





Assuming a flat prior from:
1% to 10% default rate
Optimal price: 10.5%

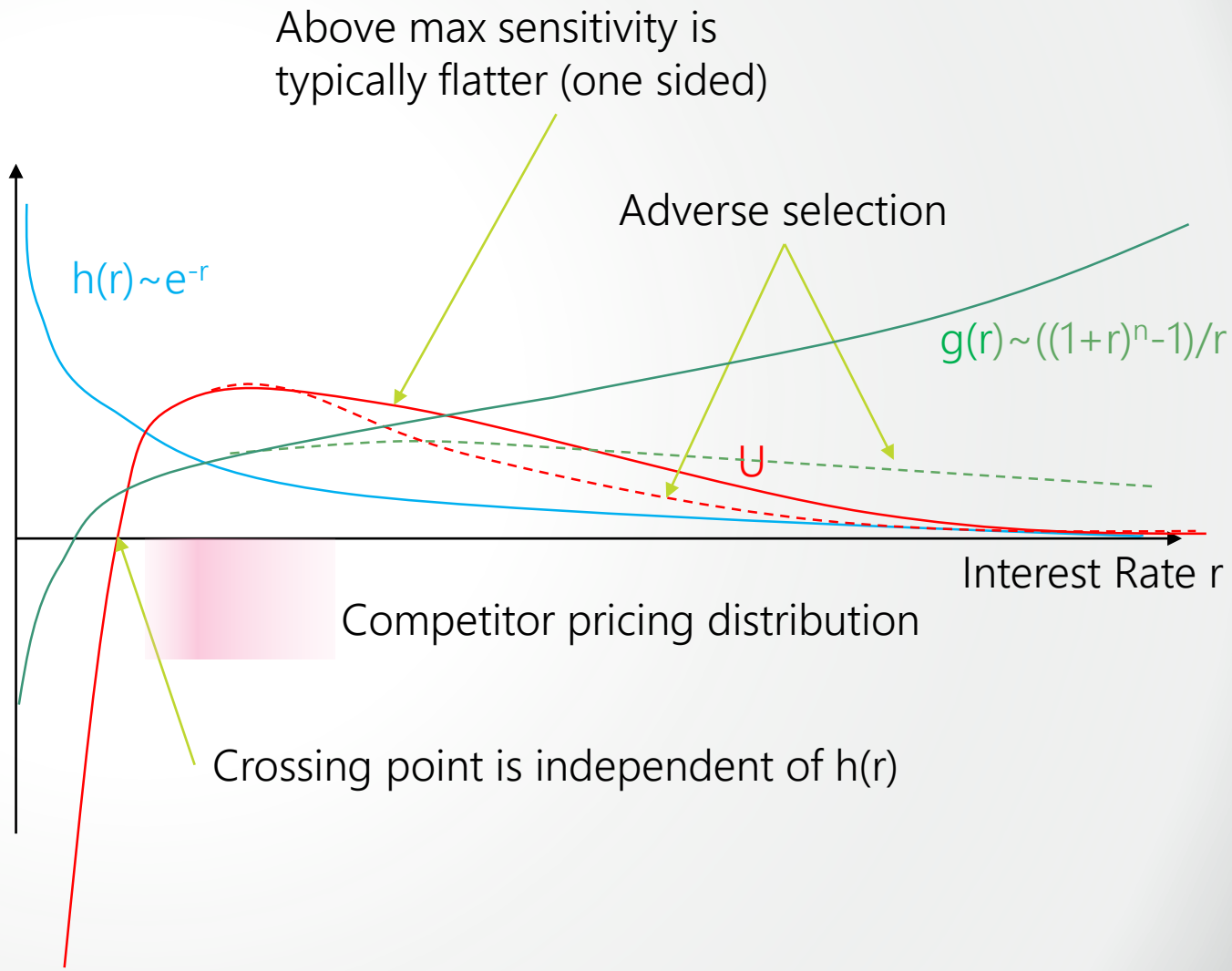
Could set higher price to constrain possibility of making a loss to below say 10% threshold…

- In this simple example it is possible to directly calculate the expected profit across the uncertainty in default rate
- In a real pricing optimisation problem this would require an optimisation over a Monte-Carlo simulation across all the parameter uncertainties. This optimisation will be complex as the random noise in the MC will make convergence harder

General observations about price sensitivity

Typically utility, U, structured in the following way:

- $U = h(r).(g(r) - \alpha.c)$ where
  - h(r) is the £volume of new business at rate r
  - g(r) is the discounted lifetime value per £ of new business at rate r (taking account of costs and credit losses)
  - c is the lifetime average capital



Types of Assumptions and Simplifications

Two typical types of approach are used to make the problem more easily tractable:

- Make assumptions on model factors that are difficult to estimate – this is often done implicitly and potentially arbitrarily (e.g. assume default rates constant over time, effects of price elasticity ignored etc).
- Apply additional smoothness constraints: (e.g. make price monotonic by term and risk group, achieve constant margin or RAROC for each segment)

The former approach leads to spurious confidence in pricing solutions – if the assumptions made have no grounding then the strategy wont be "optimal"

The second approach proposes some sort of "fairness" in pricing. There is however nothing that guarantees that getting equal margin on every loan will maximise any specific utility measure, instead the benefit on equalising return from different segments is:

1) Pricing "unfairly" might be exploitative and lead to regulatory censure
2) Benefits spread over many segments are more likely to be robust (if one segment changes behaviour to be unprofitable then there are likely other segments less affected)

Many organisations will price to achieve hurdle profitability under stressed/conservative assumptions for default rate and prepayment

Capital Regulations and Competitive pricing position

- Current regulatory Pillar 1 capital requirement is additive. This implies that there are regions where IRB models will be beneficial relative to Standardised approach and vice versa.
- In certain parts of the risk distribution (e.g. low PD mortgages) the difference can be a factor 5 or more. This magnitude of difference is likely to dominate the competitiveness
- Similarly Peer to Peer lenders have no direct capital requirement – instead driven by their investors (often institutional asset managers for insurers and pension companies)
- Basel III finalisation and application of output floors will change the mechanism – with offsetting between segments permitted. Effectively will be fixed that IRB lenders will have a 27.5% capital advantage in all segments (post 2027 – more than this in the interim)

Leverage ratio similar. Ring fencing too

Comparison of IRB vs STD RW for residential

RESI PD	DT LGD IRB NOW	LTV 5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%	105%
		Ratio to Standardised																				
	0.2%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	12%	13%	16%	20%	24%	28%	33%
	0.3%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%	19%	23%	29%	35%	42%	49%
	0.6%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	28%	34%	42%	51%	61%	71%
	1.0%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	38%	40%	48%	61%	74%	88%	103%
	1.7%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	56%	68%	86%	104%	124%	145%
	2.8%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	73%	78%	94%	118%	144%	171%	200%
	4.8%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	98%	104%	126%	158%	193%	229%	268%
	8.2%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	127%	135%	163%	205%	249%	296%	346%

IRB FUTURE	Ratio to Standardised																				
0.2%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	8%	8%	7%	7%	8%	12%	13%	17%	18%	22%	19%
0.3%	15%	15%	15%	15%	15%	15%	15%	15%	15%	15%	12%	12%	10%	10%	11%	18%	19%	26%	26%	33%	28%
0.6%	22%	22%	22%	22%	22%	22%	22%	22%	22%	22%	17%	17%	14%	14%	17%	26%	28%	37%	38%	48%	41%
1.0%	31%	31%	31%	31%	31%	31%	31%	31%	31%	31%	25%	25%	21%	21%	24%	38%	40%	54%	55%	68%	59%
1.7%	44%	44%	44%	44%	44%	44%	44%	44%	44%	44%	35%	35%	29%	29%	34%	53%	57%	76%	78%	96%	84%
2.8%	60%	60%	60%	60%	60%	60%	60%	60%	60%	60%	48%	48%	40%	40%	46%	73%	78%	104%	107%	133%	115%
4.8%	81%	81%	81%	81%	81%	81%	81%	81%	81%	81%	65%	65%	54%	54%	62%	98%	105%	140%	144%	179%	155%
8.2%	105%	105%	105%	105%	105%	105%	105%	105%	105%	105%	84%	84%	70%	70%	80%	127%	135%	181%	186%	231%	200%

These are approximations only but shape of relative benefits is reflective

Output floor under Basel III finalisation complicates picture as IRB banks can offset over and under segments but however limits benefits to 72.5% of standardised

Conclusions

- Full optimisation of even a simple loan is complex and uncertain. Lending with conditional decisions (credit cards/overdrafts etc) are order of magnitude harder.

- But: hurdle rate over capital cost is likely to be tractable and reasonably robust given uncertainty in parameters over time

- Different types of organisation, depending on their capital treatment are likely to favour different niches in the market.
- Basel III finalisation due to aggregate output floor is likely to make IRB banks pursue some riskier lending (where standardised banks have been specialising)
- Basel III finalisation is likely to be a challenge for standardised banks – particularly to compete against IRB banks in the mid term (2023-2026) as floor only slowly increases.