Lessons in Developing & Applying Decision Modelling Methods

Neill Crossley
Principal Consultant
FICO

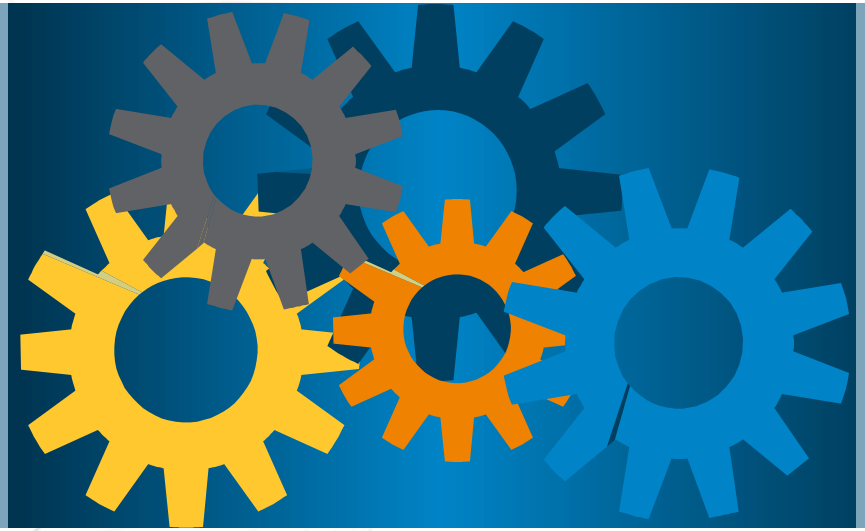
Credit Scoring and Credit Control XIII
August 28-30, 2013

Decision Modelling Introduction

- Decision focused predictions

Predictive Modelling Example

Bal01=£450
Bal02=£624
Bal03=£328
Util1=23%
Util2=31%
Util3=16%
TOB=86
etc
etc
etc
etc
…
400+
characteristics



Probability of credit default in next 12 months = **1.5%**

Score = **420**

Decision Modelling Example

Bal01=£450
Bal02=£624
Bal03=£328
Util1=23%
Util2=31%
Util3=16%
TOB=86
etc
etc
etc
etc
…
400+
characteristics

Profitability over next 12 months if we do ‘A’ = £100

Profitability over next 12 months if we do ‘C’ = £120

Profitability over next 12 months if we do ‘B’ = £80

Decision A

Decision B

Decision C

Decision Modelling Introduction

- Decision focused predictions
- Open standardized modelling framework
- Robust Methodology

FICO Development Methodology

Provides a Robust Development Framework

INPUTS

Customer & Bureau Data
Segmentations & Scores
Pricing / Profit Models
Product Metrics

Design Framework

DECISION MODELLING

Establish mathematical relationships between Actions, Reactions and Profitability

Optimisation Software Set-up

SIMULATION & OPTIMISATION

Identify best strategy scenarios subject to multiple business goals, **constraints** and forecasts

Reporting & Drill Down Analysis

DEPLOYMENT

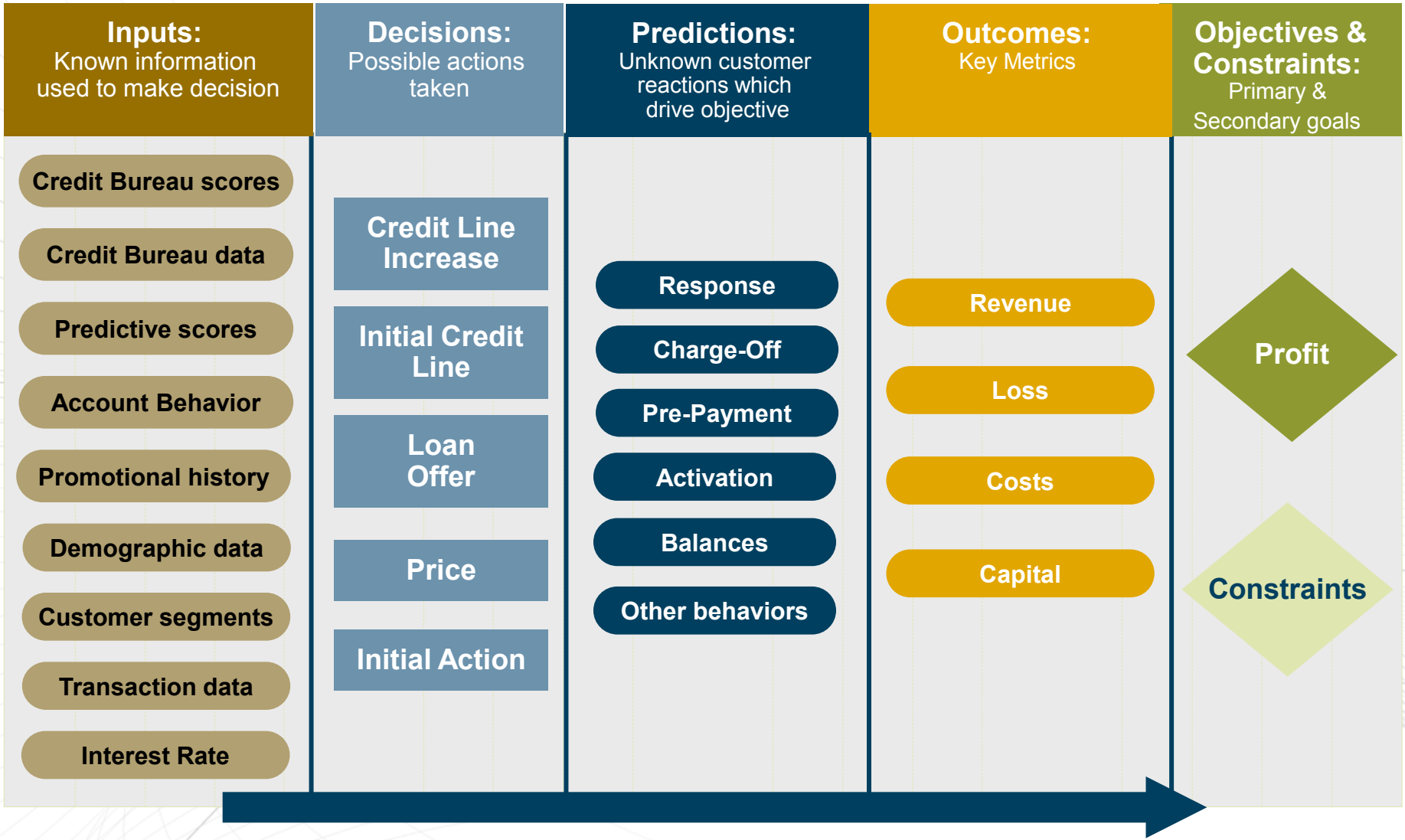
Engineer final strategy and deploy challengers as Decision Trees or Rule Sets in Production Systems

Accelerated Learning

Importance of Project Design

- Structure with Influence Diagrams
- What to Include / Exclude?

Decision Model Design:
Use Influence Diagrams to structure the problem

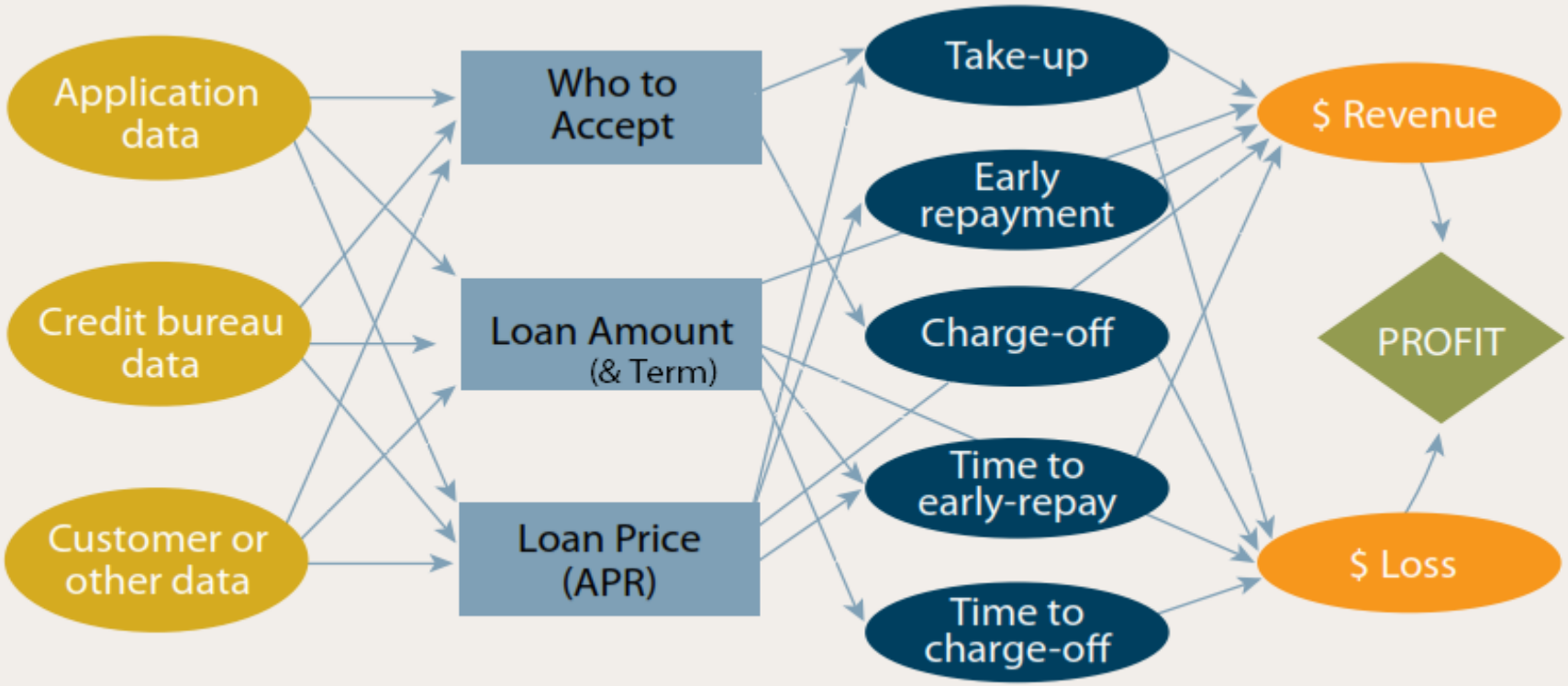


Example Decision Model Design
Multiple Decisions - Loan Amount / Term & Price

FICO

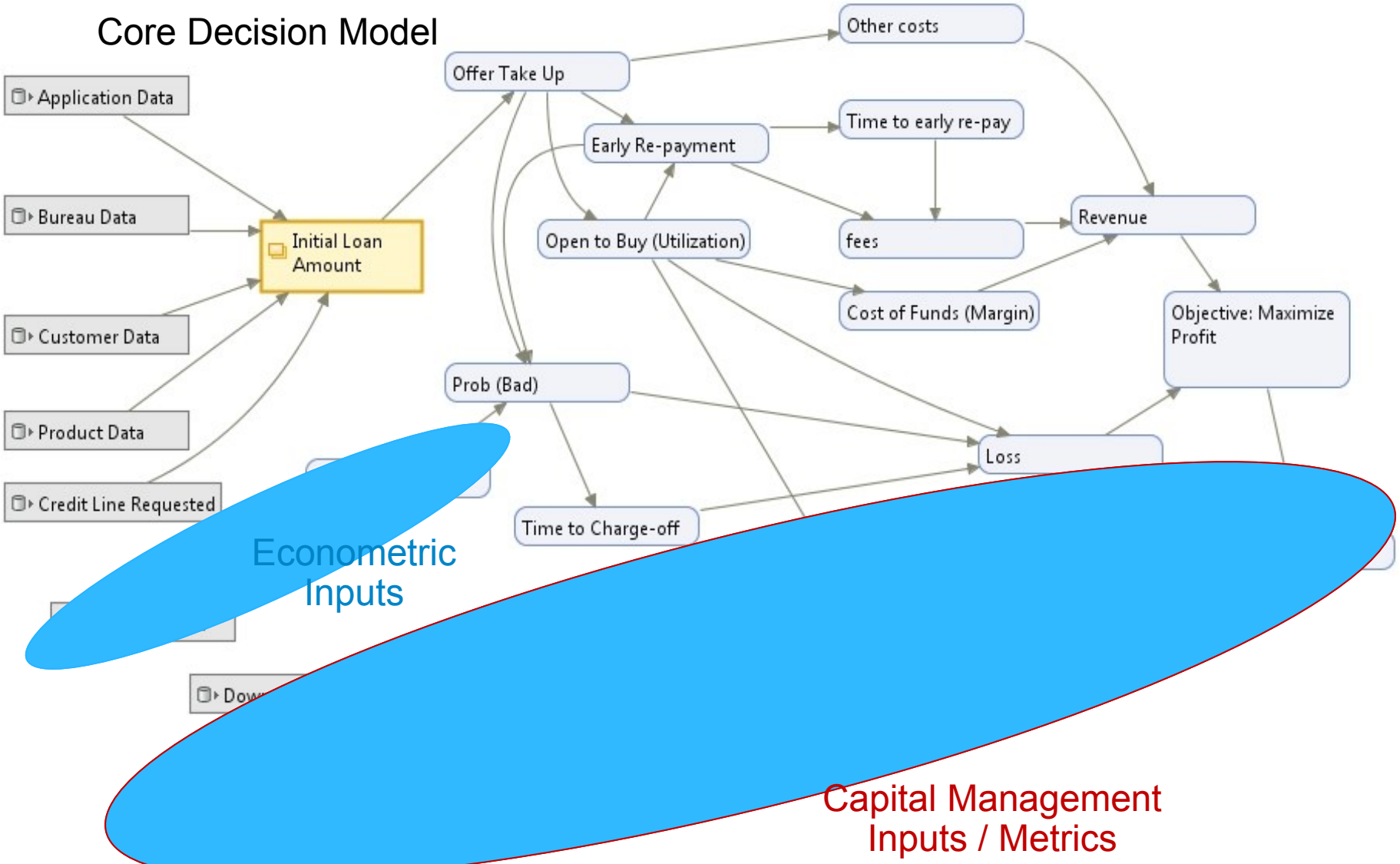
Inputs | Decisions | Predictions | Outcomes | Objectives

Simplified origination decision model



This simplified influence diagram shows how the FICO decision model drives the optimal action based on analyzing the relationships between all the elements of the decision.

Decision Model Design – more realistic example
Provides A Complete Profit Framework



Importance of Project Design

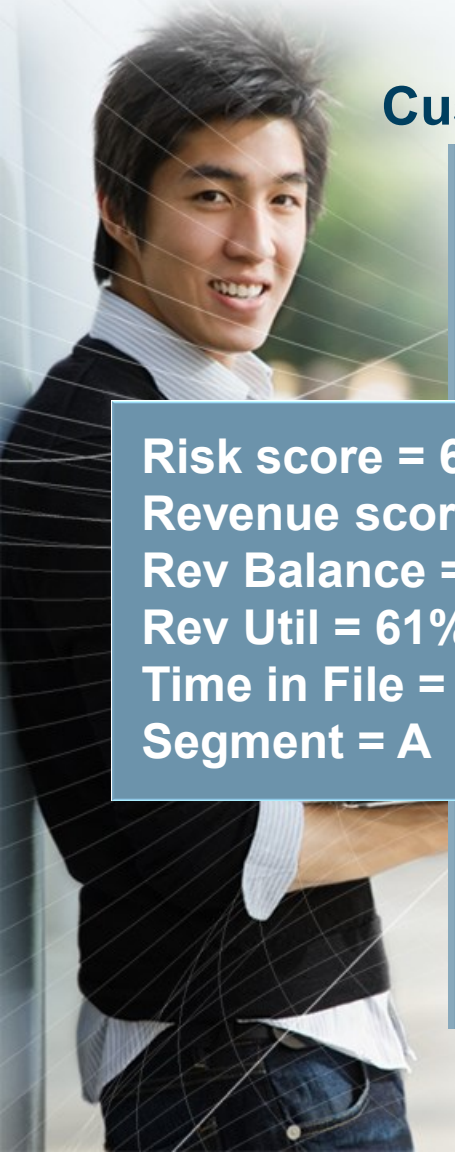
- Structure with Influence Diagrams
- What to Include / Exclude?
- Question Everything!

Action Effect Models

- Essential to understand outcomes

Action Effect Models

Evaluates Customers' Reactions to Your Actions

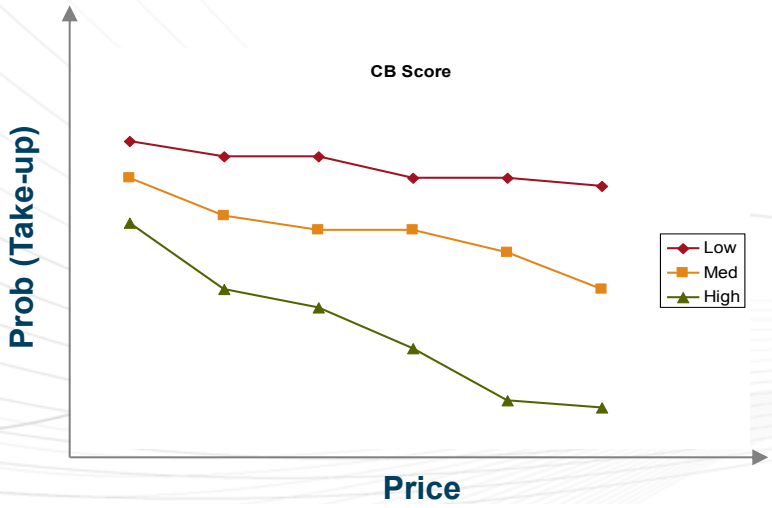


Customer	Action	Reaction
Risk score = 680 Revenue score = 720 Rev Balance = £6,250 Rev Util = 61% Time in File = 132mths Segment = A	Offer 1 — Credit Card: £3,000 Limit	E(Bal) = £1,000 E(loss) = £40 E(profit) = £105
	Offer 2 — Credit Card: £5,000 Limit	E(Bal) = £1,500 E(loss) = £65 E(profit) = £115
	Offer 3 — Credit Card: £9,000 Limit	E(Bal) = £1,750 E(loss) = £120 E(profit) = £95

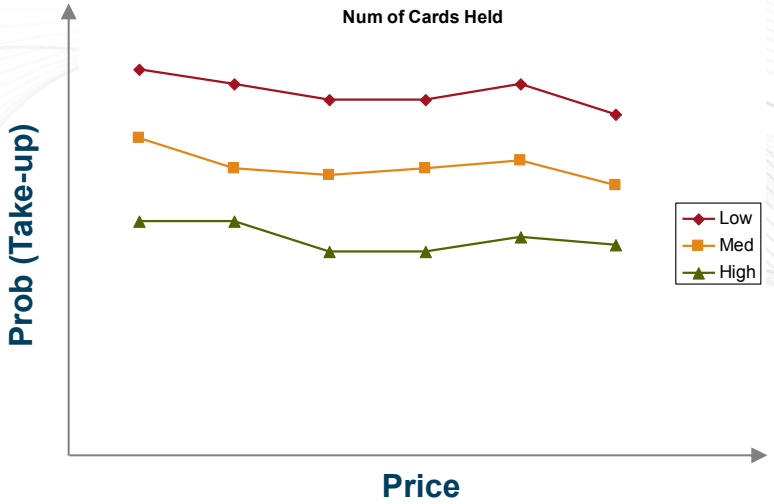
Action Effect Models – Variable Selection

Determine Variables that are Predictive & have Strong Interactions

STRONG INTERACTIONS



WEAK INTERACTIONS



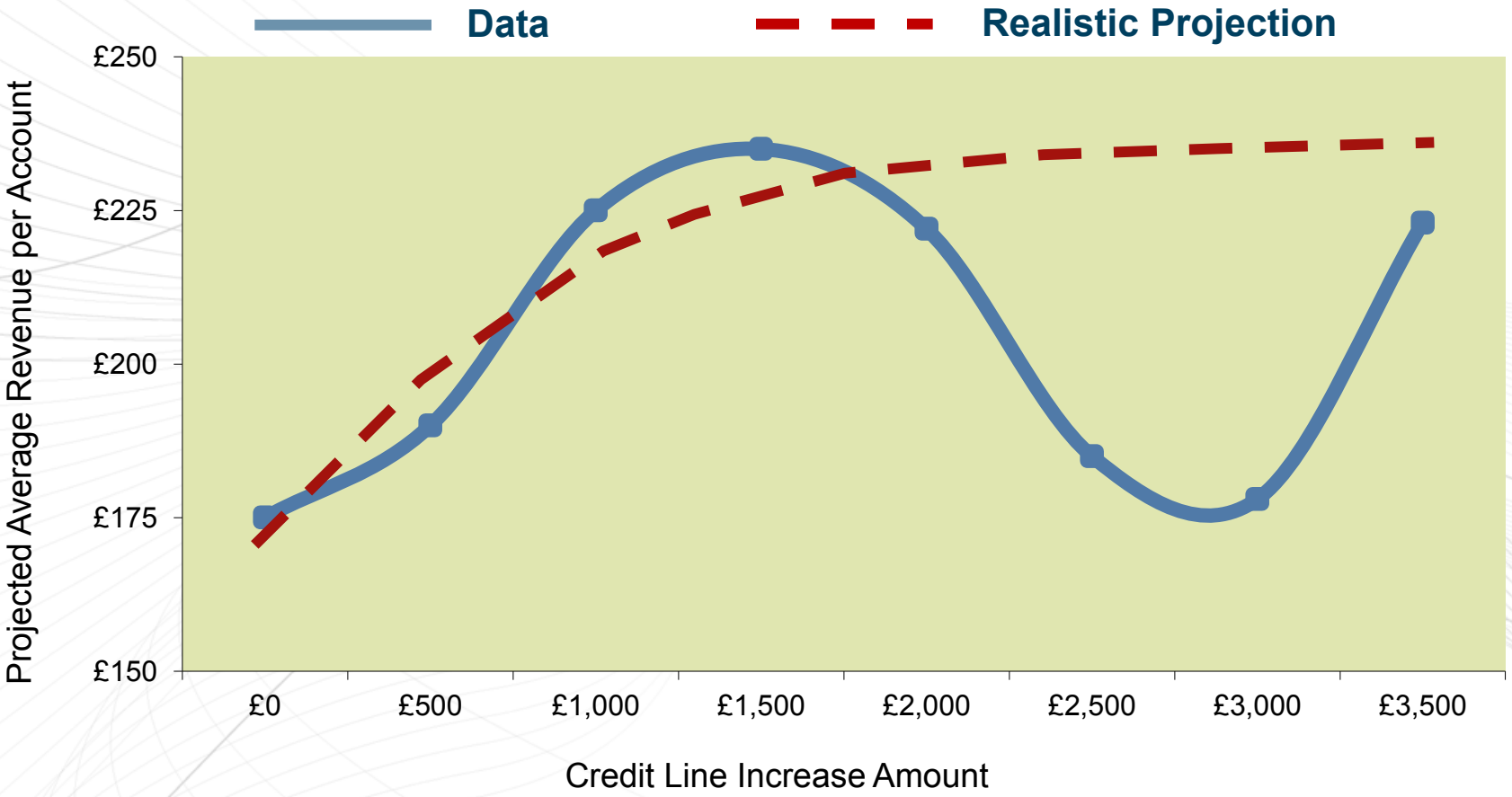
Action Effect Models

- Essential to understand outcomes
- Account for Data Bias
- Keep it simple

Action Effect Models - Account for Data Bias

Infusing business expertise into action-effect models

The data shows the following relationship between Credit Line Increase amount and Projected Revenue – WHY?



Reasons for Data Bias

Why data driven interaction variables don't always capture the action-effects:

- **Inherent historical data bias** - the historical actions usually are targeted. The result is often data gaps.
- **Causal effect vs. correlation effect** - the primary purpose of action-effect modeling is to capture the "causal effect". However, what we observe is often overwhelmed by the "correlation effect", which occurs when performance is highly correlated with the targeted profiles.
- **Limitations in the historical action range**
- **Confounding effects** - there may be many strategies in different decision areas that may impact the observed performance. Changes in market or economic conditions may also impact the observed performance.

Solutions:

- Broader more comprehensive data will always improve the models.
- Most effective - Experimentally Designed test and learn strategy

Building action-effect models
Interpolation and extrapolation of data

- Consider use of Experimental Design and Learning Strategy approaches
- Necessary to accommodate for data holes and biases of past strategies
- Data Driven + Judgmental assessment based on data and experience
- Need to consider potential data bias and confidence levels

Loan Take Up Rate	Price Increment	0%	+1%	+2%	+4%	+6%
Application Score	**Credit Bureau Score**					
651 to 670	0-500				**66%**	60%
	501-550			**73%**	64%	
	551-600	**90%**	**85%**			
	601-650	**88%**	78%			
	651-700	**85%**		65%		
	701-999	**80%**				

Building action-effect models

Interpolation and extrapolation of data – to infer performance

- Consider use of Experimental Design and Learning Strategy approaches
- Necessary to accommodate for data holes and biases of past strategies
- Data Driven + Judgmental assessment based on data and experience
- Need to consider potential data bias and confidence levels

Loan Take Up Rate	Price Increment	0%	+1%	+2%	+4%	+6%
Application Score	**Credit Bureau Score**					
651 to 670	0-500	92%	89%	76%	**66%**	60%
	501-550	91%	87%	**73%**	64%	59%
	551-600	**90%**	**85%**	71%	62%	56%
	601-650	**88%**	78%	67%	58%	51%
	651-700	**85%**	75%	65%	55%	45%
	701-999	**80%**	69%	60%	50%	35%

Building action-effect models
Understand where inference is strong and weak

- Consider use of Experimental Design and Learning Strategy approaches
- Necessary to accommodate for data holes and biases of past strategies
- Data Driven + Judgmental assessment based on data and experience
- Need to consider potential data bias and confidence levels

Loan Take Up Rate	Price Increment	0%	+1%	+2%	+4%	+6%
Application Score	**Credit Bureau Score**					
651 to 670	0-500	92%	89%	76%	**66%**	60%
	501-550	91%	87%	**73%**	64%	59%
	551-600	**90%**	**85%**	71%	62%	56%
	601-650	**88%**	78%	67%	58%	51%
	651-700	**85%**	75%	65%	55%	45%
	701-999	**80%**	69%	60%	50%	35%

Overcoming Data Bias
Extrapolation Factors

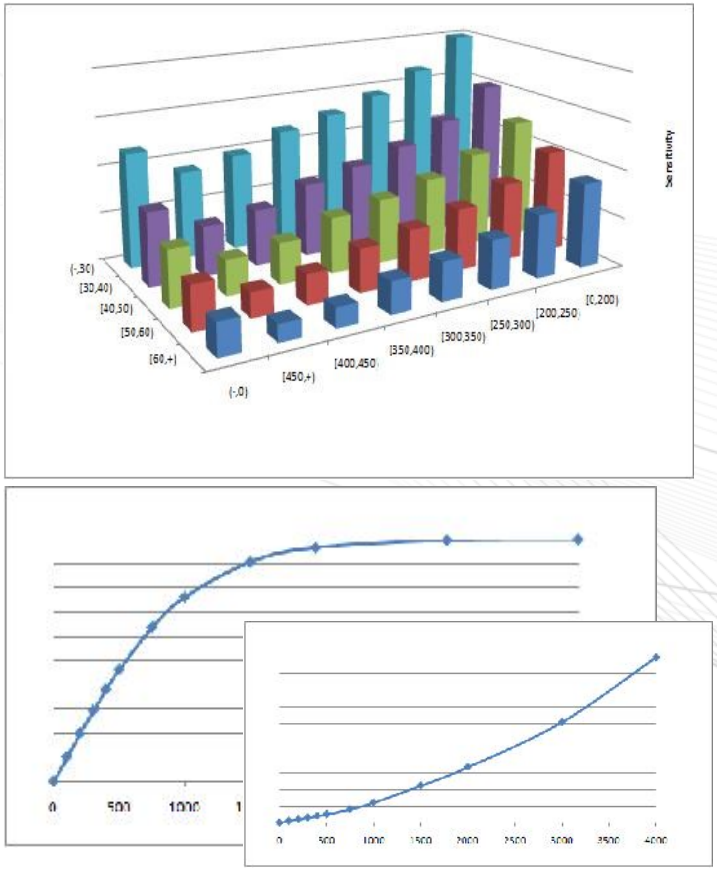
- Data Extrapolation (& Interpolation) approaches are used to understand the relationship between Action & Effect.
- When developing the component models, it is important to focus on the trend and the relationship between sub-segments, rather than the point estimates.

We use Three sets of factors to influence the Extrapolation process:

Sensitivity
- Where we look to identify how much the performance would change given changes in the **model characteristics** we are considering

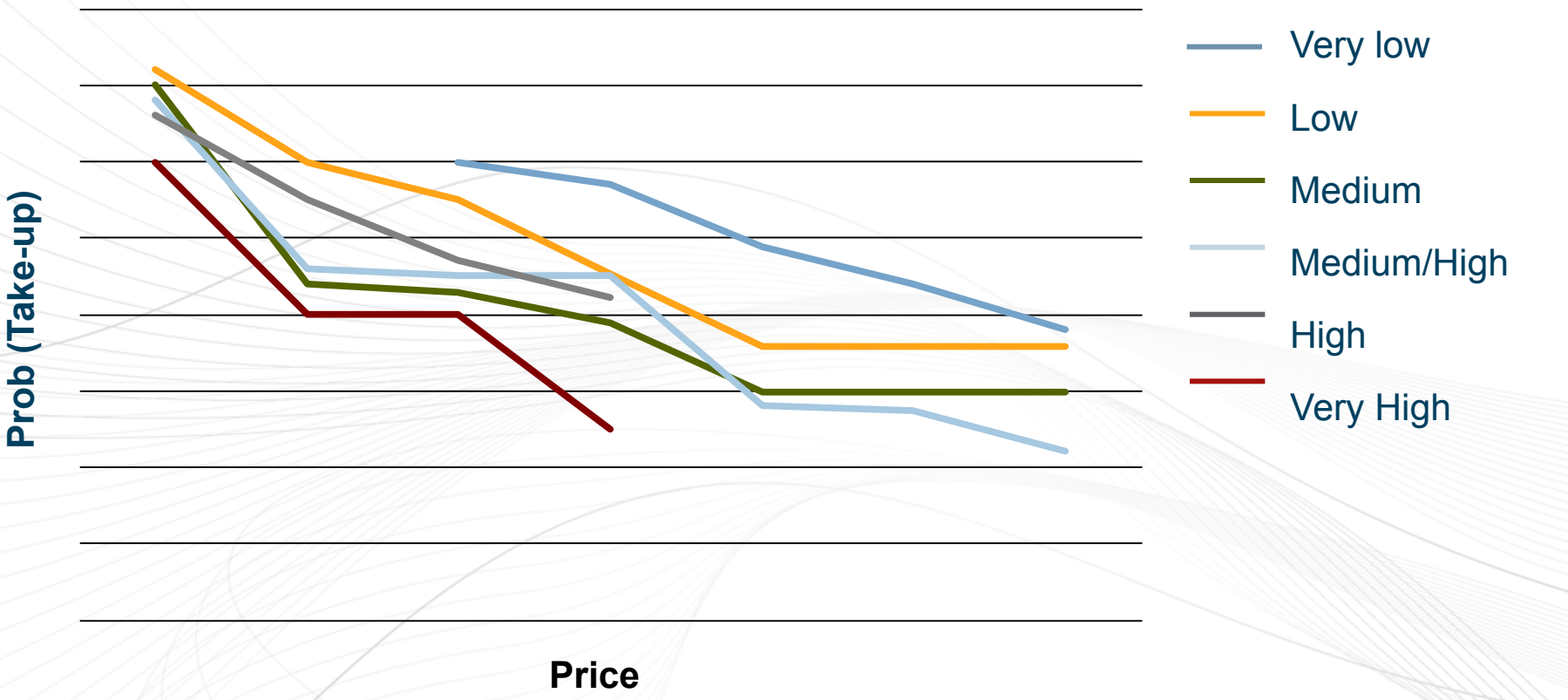
Shape
- Where we look to identify how much performance would change given changes in the **actions** we are considering

Trend
- Where we identify how overall performance would change given changes in **both the model characteristics and the actions** we are considering



Action Effect Models – Account for Data Bias
Important to smooth relationships between actions 1

OBSERVED TAKE-UP RATES BY CREDIT BUREAU SCORE

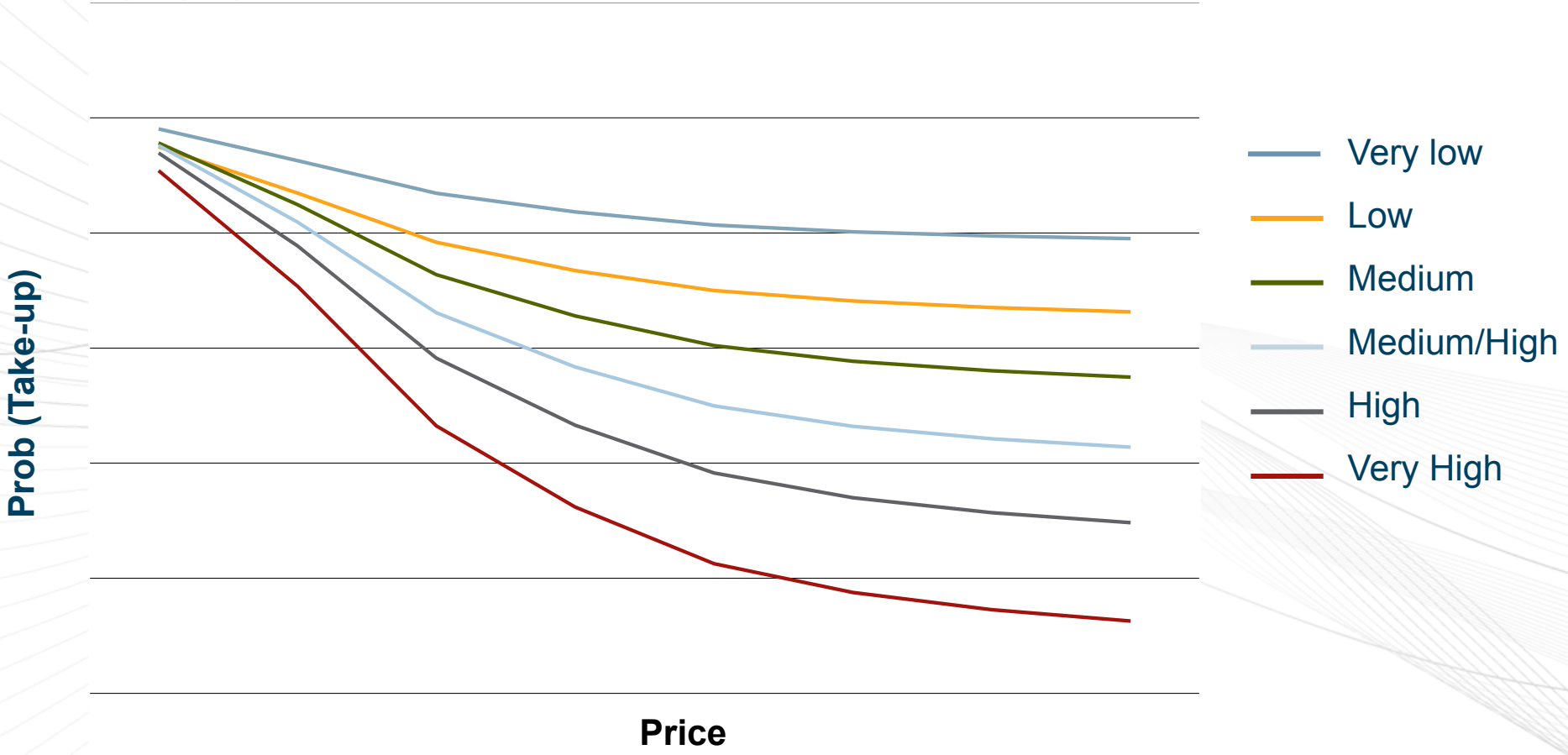


Business Expectations

- We expect to see:
  - For a given bureau score, probability of take-up decreases as price increases
  - Across score bands, sensitivity to pricing increases as the CB score increases

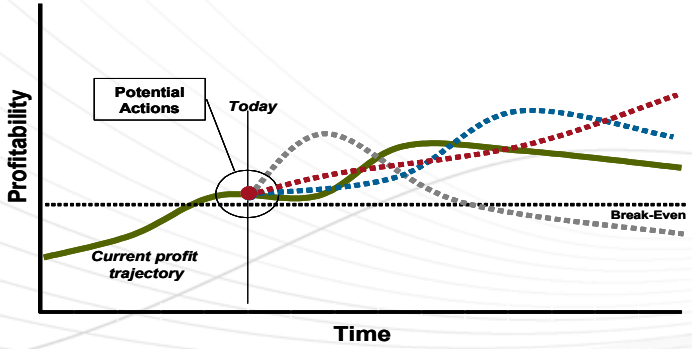
Action Effect Models – Account for Data Bias
Important to smooth relationships between actions 2

EXTRAPOLATED TAKE-UP RATES BY CREDIT BUREAU SCORE



Validating the Decision Model

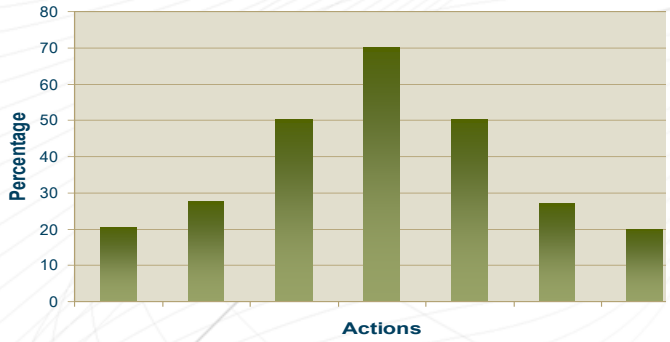
Simulate business as usual



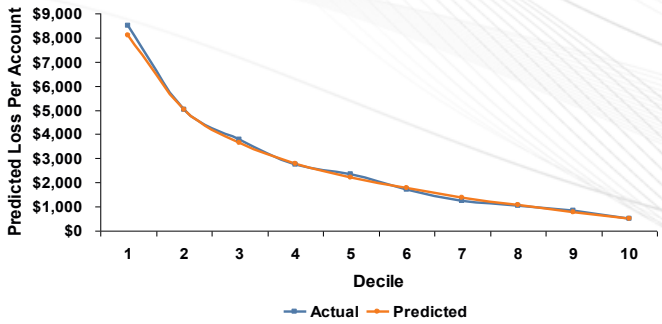
Review targeting profiles

Behavior_Score	Utilization							
	Low to 0.9900	0.9900 to 9.990	9.990 to 29.99	29.99 to 49.99	49.99 to 69.99	69.99 to 89.99	89.99 to High	Total
Low to 599.9	3.05 2.67 114	0.03 0.02 109	. 0.04 0	. 0.00 0	. 0.02 0	. 0.00 0	0.00 0.02 3	3.07 2.77 111
599.9 to 649.9	0.00 0.00 76	. 0.00 0	. 0.00 0	. 0.00 0	. 0.00 0	0.00 0.01 10	0.00 0.06 4	0.00 0.06 6
649.9 to 679.9	0.00 0.01 64	0.00 0.01 25	0.00 0.01 32	0.02 0.03 46	0.03 0.07 46	0.04 0.12 32	0.02 0.26 8	0.12 0.51 23
679.9 to 699.9	0.02 0.02 72	0.01 0.01 71	0.03 0.04 84	0.04 0.05 93	0.06 0.07 89	0.09 0.11 85	0.04 0.13 31	0.29 0.42 69
699.9 to 709.9	0.02 0.02 91	0.01 0.01 88	0.01 0.01 100	0.02 0.02 107	0.02 0.02 98	0.03 0.03 95	0.01 0.02 60	0.12 0.13 90
709.9 to 729.9	0.04 0.04 101	0.02 0.02 87	0.03 0.02 106	0.03 0.02 112	0.03 0.02 109	0.02 0.02 108	0.01 0.01 69	0.17 0.17 101
729.9 to 749.9	0.03 0.02 114	0.01 0.01 104	0.01 0.01 96	0.00 0.00 114	0.01 0.01 114	0.00 0.00 114	0.00 0.00 27	0.06 0.06 105
749.9 to 769.9	0.00 0.00 114	0.00 0.00 114	0.00 0.00 114	0.00 0.00 114	. 0.00 0	. 0.00 0	. 0.00 0	0.01 0.01 105
769.9 to High	22.83 20.80 110	3.44 3.25 106	4.76 4.60 103	3.27 3.03 108	2.53 2.36 107	2.14 2.02 106	57.19 59.78 96	96.15 95.85 100
Total	25.99 23.58 110	3.52 3.35 105	4.85 4.74 102	3.38 3.16 107	2.68 2.59 104	2.31 2.30 101	57.28 60.28 95	100.00 100.00 100

Review action distributions



Review actual vs. predicted



Power of Scenario Analysis

- Compare to BAU – results are directional
- Know where your model is weak
- Stress Test

Scenario Analysis
Optimisation Solvers Answer Different "What If" Questions

FICO

Decision Model

Customer	Action	Reaction
	Low Price, Low Line	P(Act)=70%, E(Rev)=£120
	High Price, High Line	P(Act)=65%, E(Rev)=£130
	Low Price, High Line	P(Act)=85%, E(Rev)=£150

Solver

Portfolio	Action	Reaction
	Low Margin, Low Exposure	£5 BB Annual Profitability
	High Margin, Low Exposure	£5.2 BB Annual Profitability
	Low Margin, High Exposure	£5.32 BB Annual Profitability

Basic Scenario Analysis Example

Limit Offer Example – Impact of Exposure Constraint

Objective: Maximise Profit

Scenario 1:
No Constraints

3 x £1000
3 x £3000
4 x £7000

Incremental Expected Profit

Customer	1	2	3	4	5	6	7	8	9	10
Action										
£1000	£45	£30	£50	-£10	£40	£20	£50	£25	£20	£50
£3000	£65	£20	£65	£10	£20	£40	£60	£30	£15	£65
£7000	-£50	£5	£30	-£40	£20	£100	£80	£35	£10	£75

Exposure = £40,000 **Profit = £520**

Scenario 2:
Constraint:
Exposure<= £32,000

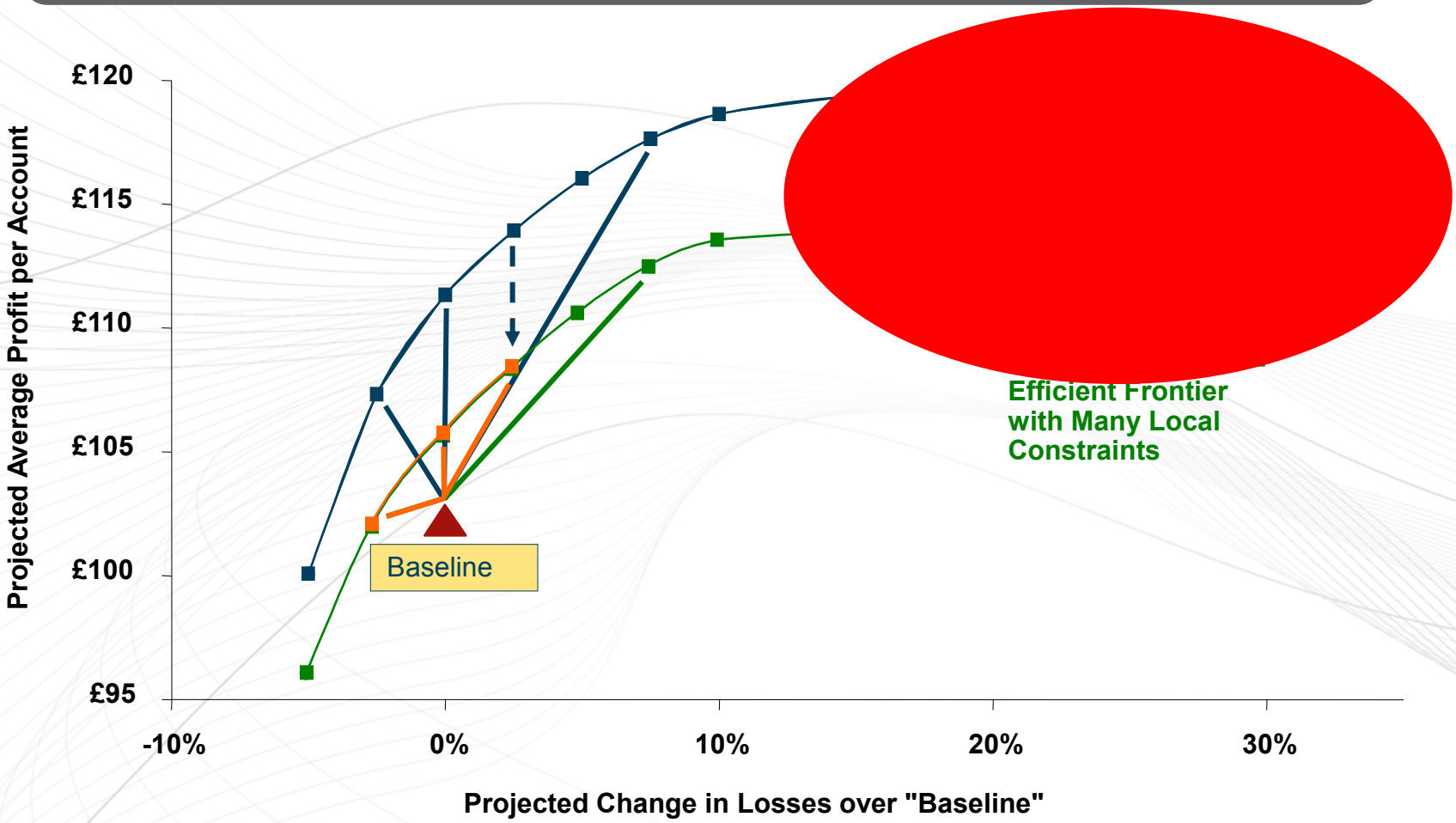
Incremental Expected Profit

Customer	1	2	3	4	5	6	7	8	9	10
Action										
£1000	£45	£30	£50	-£10	£40	£20	£50	£25	£20	£50
£3000	£65	£20	£65	£10	£20	£40	£60	£30	£15	£65
£7000	-£50	£5	£30	-£40	£20	£100	£80	£35	£10	£75

Exposure = £32,000 **Profit = £505**

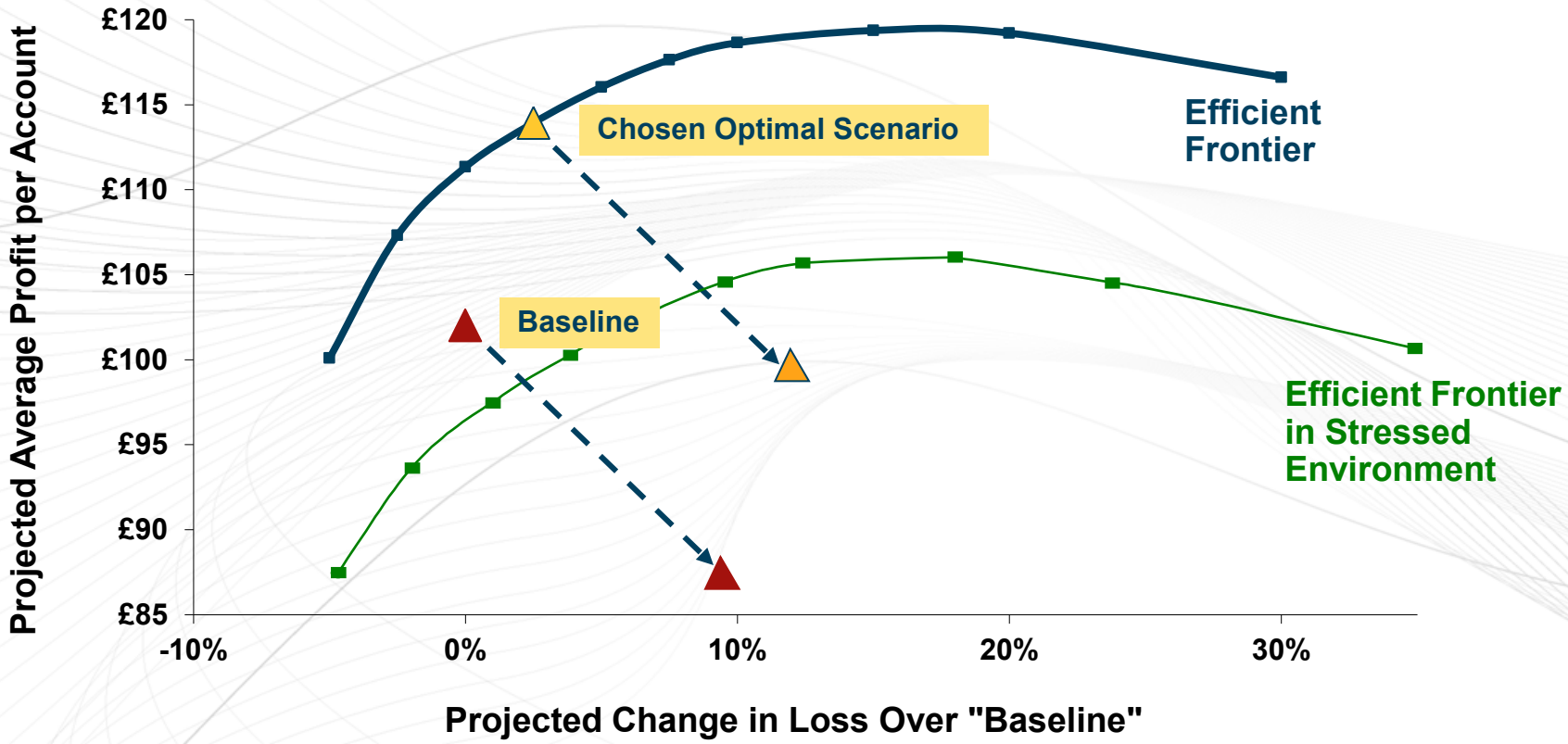
Scenario Analysis
Appropriately constraining the optimization problem

Layering on global and local constraints restricts the optimization space and the potential improvement that can be achieved



Scenario Analysis
Adapting to potential market changes

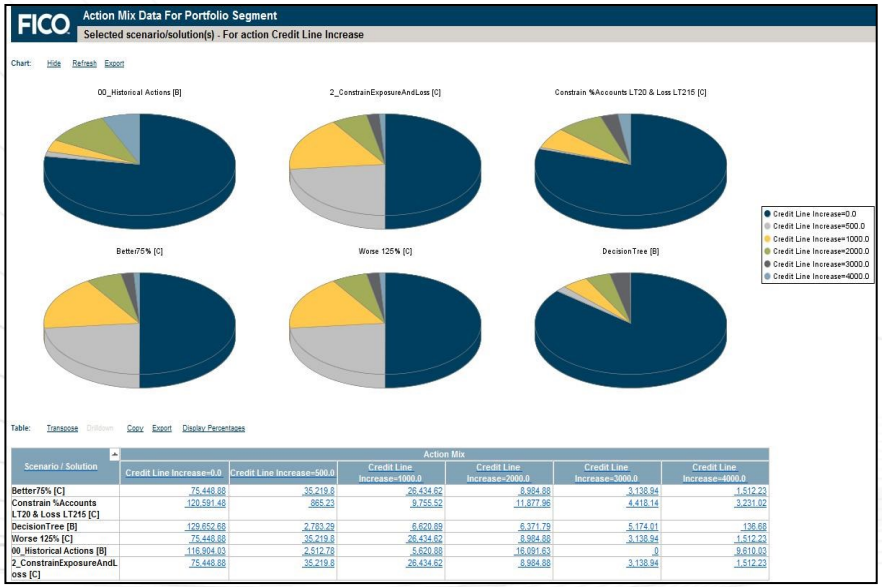
Simulating profit outcomes in a Stressed environment



Scenario Analysis

Compare and drill down into different scenarios & metrics

FICO



Scenario / Solution	Action Mix					
	Credit Line Increase=0.0	Credit Line Increase=500.0	Credit Line Increase=1000.0	Credit Line Increase=2000.0	Credit Line Increase=3000.0	Credit Line Increase=4000.0
Better75% [C]	75,448.88	35,219.8	26,434.62	8,984.88	3,138.94	1,512.23
Constrain %Accounts LT20 & Loss LT215 [C]	120,591.48	865.23	9,755.52	11,877.96	4,418.14	3,231.02
DecisionTree [B]	129,652.68	2,783.29	5,620.89	6,371.79	5,174.01	136.68
Worse 125% [C]	75,448.88	35,219.8	26,434.62	8,984.88	3,138.94	1,512.23
00_Historical Actions [B]	116,904.03	2,612.78	5,620.88	16,091.63	0	9,610.93
2_ConstrainExposureAndLoss [C]	75,448.88	35,219.8	26,434.62	8,984.88	3,138.94	1,512.23

Key Metrics per Eligible Account	No Action	Baseline	Option # 1 Exp.per Increased <= £1,856; % Inc <= 16.8%; Loss Rate <= 31.77%	Option # 2 Exp. per Increased <= £2,000; % Inc <= 20%; Loss Rate <= 31.77%
Revenue	£ 204.86	£ 210.00	£ 216.27	£ 217.49
Loss	£ 62.78	£ 66.71	£ 65.63	£ 66.42
Loss Rate (Loss/Revenue)	30.64%	31.77%	30.35%	30.54%
Profit	£ 142.09	£ 143.29	£ 150.64	£ 151.07
Percent Increased	0.0%	16.8%	16.8%	20.0%
Bad Rate	1.20%	1.20%	1.20%	1.20%
% of Revolvers Increased	0.0%	29.9%	38.8%	45.5%
% of Transactors Increased	0.0%	7.5%	1.1%	1.8%
Current Exposure	£ 6,741	£ 6,741	£ 6,741	£ 6,741
Increased Exposure (per Increased Account)	£ -	£ 1,856	£ 1,856	£ 2,000
Increased Exposure	£ -	£ 312	£ 312	£ 400
Profit Improvement	£ (1.20)	£ -	£ 7.35	£ 7.78
Profit % Improvement	-0.84%	0.00%	4.88%	5.15%

View as: HTML HTML-L PDF PDF-L | Help

FICO **Drill-down Metric Data Report**

Table: Transpose Copy Export

1_Unconstrained [B] / 00_Historical Actions [B]	-	Metric Value					
		0 / 0	500 / 0	1000 / 0	2000 / 0	3000 / 0	4000 / 0
Frequency	Total	54,535.69	19,587.55	26,604.33	10,550.35	3,586.41	2,039.7
Frequency	Percentage	36.18	12.99	17.65	7	2.38	1.35
Average Balance Last 6 Months	Average	$1,193	$2,994	$2,773	$4,235	$5,162	$5,911
Average Purchases Last 6 Months	Average	$235	$215	$212	$406	$594	$1,033
Average Utilization Last 6 Months	Average	14%	38%	36%	51%	61%	69%
Behavior Score	Average	715	702	717	719	719	723
Current Balance	Average	$1,173	$2,745	$2,536	$3,529	$4,341	$5,889
Current Limit	Average	$7,298	$7,687	$7,614	$7,712	$7,208	$7,328
Current Utilization	Average	14	35	34	44	53	70
Interest Revenue Last 6 Months	Average	$79	$227	$193	$273	$304	$283
Number of Months Revolving Last 12 Months	Average	4.3	9.3	9.6	10.1	9.9	9.6
Open To Buy	Average	$7,591	$6,425	$6,560	$5,656	$4,341	$2,798
Revenue At Observation	Average	$137	$335	$272	$398	$433	$422
RevolverTransactorFlag	Average	27%	75%	75%	62%	62%	83%
Time On Books	Average	76	63	62	61	53	86

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Acct ID	Cr Line Inc	AvPur Last6	Curr Util	No Mths Rev12	Beh Score	CB Risk Score	Curr Limit	TOB	Int Rev L6	Revenue	Loss	Profit	NewCrLine	pbad	ProfitDueToCLI
2	1	0	665	82.64	12	663	726	13500	55	828.80	1343.66	1396.46	-52.80	13500	10.78%	0
3	1	500	665	82.64	12	663	726	13500	55	828.80	1423.03	1448.18	-25.15	14000	10.78%	27.65063292
4	1	1000	665	82.64	12	663	726	13500	55	828.80	1461.26	1499.90	-38.64	14500	10.78%	14.16306371
5	1	2000	665	82.64	12	663	726	13500	55	828.80	1505.31	1603.35	-98.03	15500	10.78%	-45.22723351
6	1	3000	665	82.64	12	663	726	13500	55	828.80	1531.57	1706.79	-175.22	16500	10.78%	-122.4139365
7	1	4000	665	82.64	12	663	726	13500	55	828.80	1543.95	1810.23	-266.28	17500	10.78%	-213.4760238
8	2	0	457	14.00	7	746	738	10500	55	59.24	32.69	87.31	-54.62	10500	0.96%	0
9	2	500	457	14.00	7	746	738	10500	55	59.24	49.62	91.46	-41.84	11000	0.96%	12.77914844
10	2	1000	457	14.00	7	746	738	10500	55	59.24	57.15	95.62	-38.47	11500	0.96%	16.14909115
11	2	2000	457	14.00	7	746	738	10500	55	59.24	64.30	103.94	-39.63	12500	0.96%	14.98524375
12	2	3000	457	14.00	7	746	738	10500	55	59.24	68.07	112.25	-44.19	13500	0.96%	10.43408229
13	2	4000	457	14.00	7	746	738	10500	55	59.24	70.32	120.57	-50.24	14500	0.96%	4.377447917
14	3	0	121	101.78	12	654	636	8500	52	848.29	1084.75	897.57	187.18	8500	10.78%	0
15	3	500	121	101.78	12	654	636	8500	52	848.29	1150.82	950.37	200.45	9000	10.78%	13.27458891
16	3	1000	121	101.78	12	654	636	8500	52	848.29	1188.23	1003.17	185.06	9500	10.78%	-2.121655561
17	3	2000	121	101.78	12	654	636	8500	52	848.29	1227.29	1086.14	141.15	10500	10.78%	-64.34386554
18	3	3000	121	101.78	12	654	636	8500	52	848.29	1248.73	1189.58	59.15	11500	10.78%	-146.341658
19	3	4000	121	101.78	12	654	636	8500	52	848.29	1260.54	1293.02	-32.48	12500	10.78%	-237.9808823
20	4	0	536	3.07	0	753	785	12000	44	0.00	57.31	65.63	-8.32	12000	0.87%	0
21	4	500	536	3.07	0	753	785	12000	44	0.00	58.94	68.36	-9.42	12500	0.87%	-1.098697917
22	4	1000	536	3.07	0	753	785	12000	44	0.00	60.13	71.09	-10.96	13000	0.87%	-2.643489583
23	4	2000	536	3.07	0	753	785	12000	44	0.00	61.47	76.56	-15.09	14000	0.87%	-6.773958333
24	4	3000	536	3.07	0	753	785	12000	44	0.00	62.07	82.03	-19.97	15000	0.87%	-11.64791667
25	4	4000	536	3.07	0	753	785	12000	44	0.00	62.26	87.50	-25.24	16000	0.87%	-16.91840278

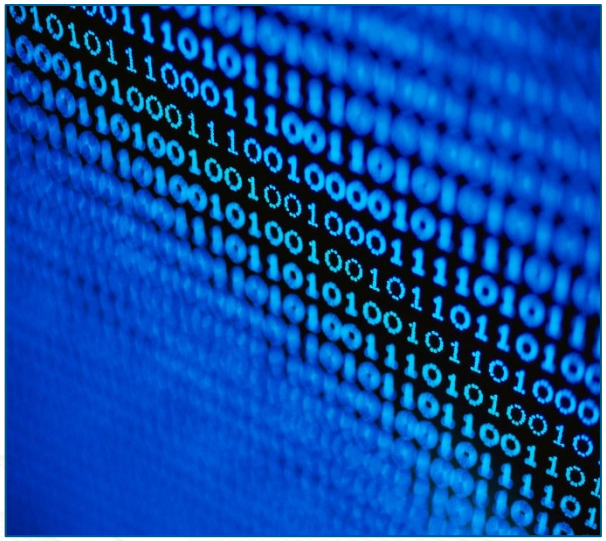
From Scenarios to Decision Strategies

- Palatability v Power
- Regulatory Review
- Tree Aware Optimization

Decision Modelling & Optimisation
Deployment Options

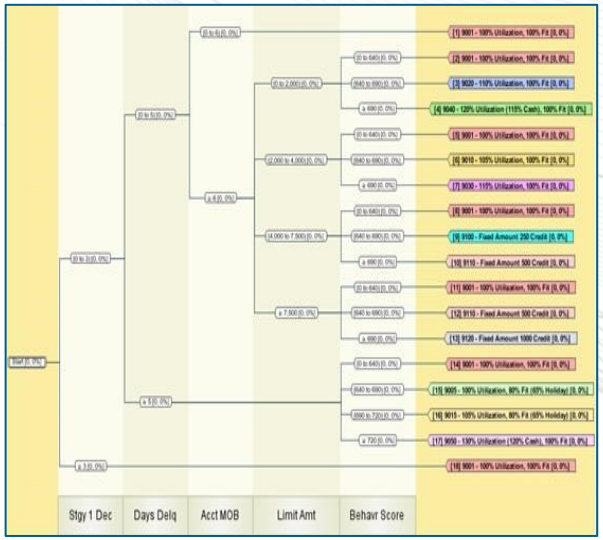
1) Directly from Optimization Process

- » Used more to support Marketing solutions
- » Puts onus on accuracy of Decision Model
- » Can be seen as Black Box – difficult to clearly explain reason for each decision
- » Can be highly efficient

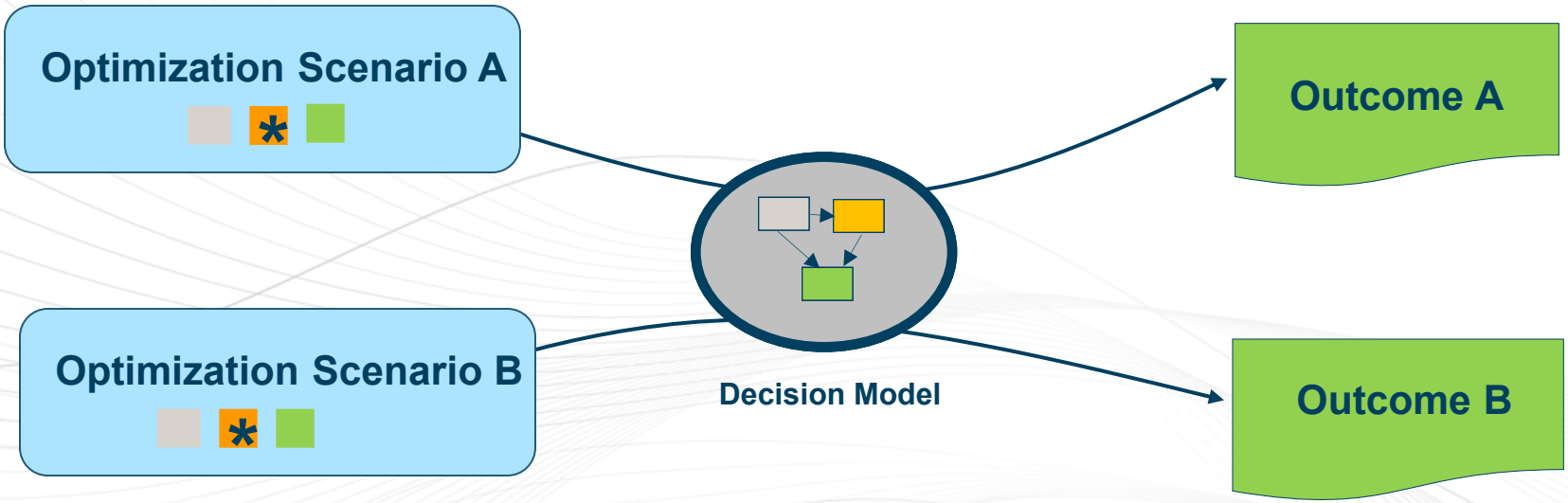


2) Conversion into Decision Tree / Rule Set / Strategy

- » Allows for final business review/ refinement
- » Allows for full audit and regulatory review
- » Every decision is explainable
- » Often easier to implement into production
- » Can trade off power v palatability

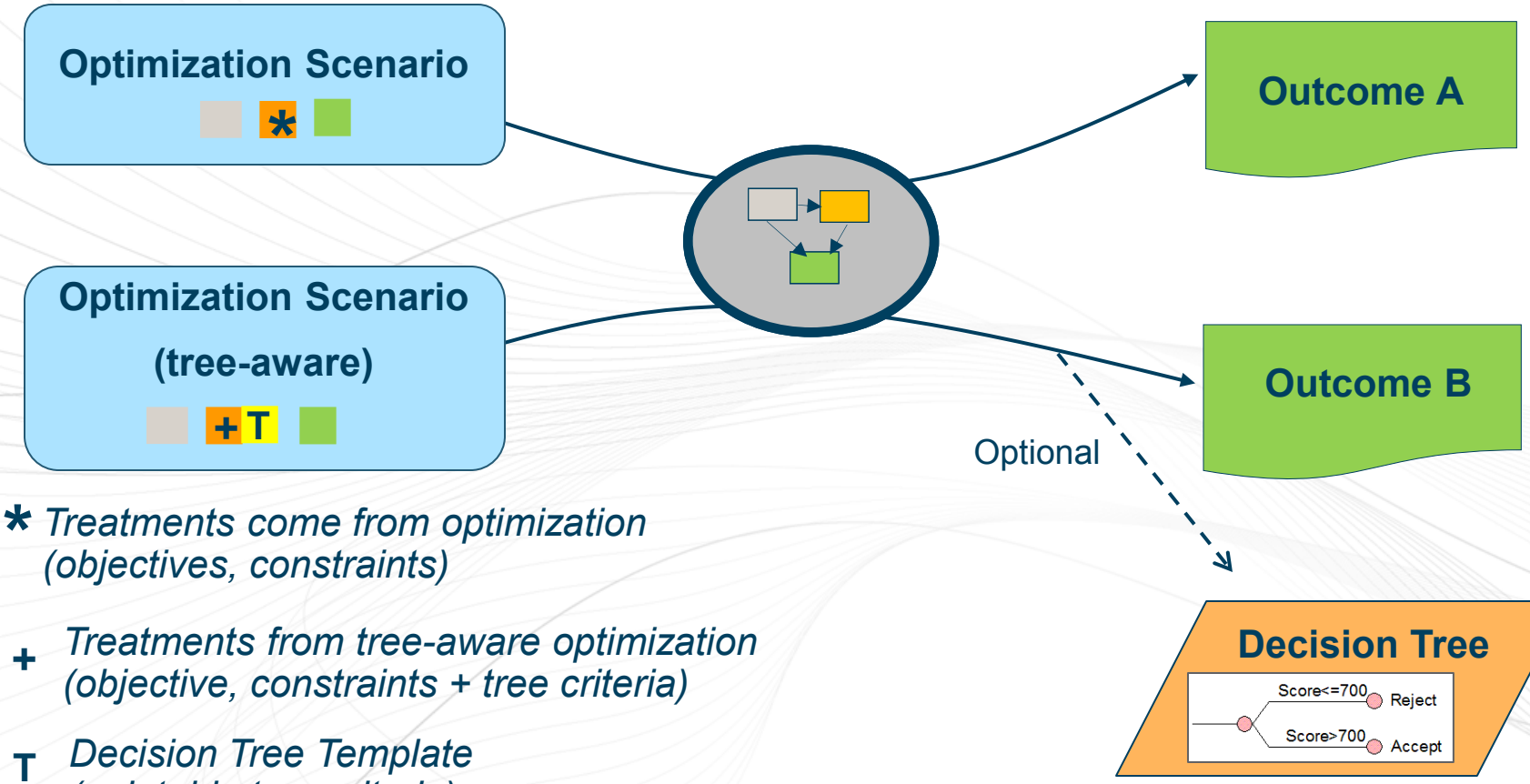


Standard Optimization Scenario Analysis



* *Treatments come from optimization (differing objectives, constraints)*

Tree-aware Optimization Scenario Analysis and Output

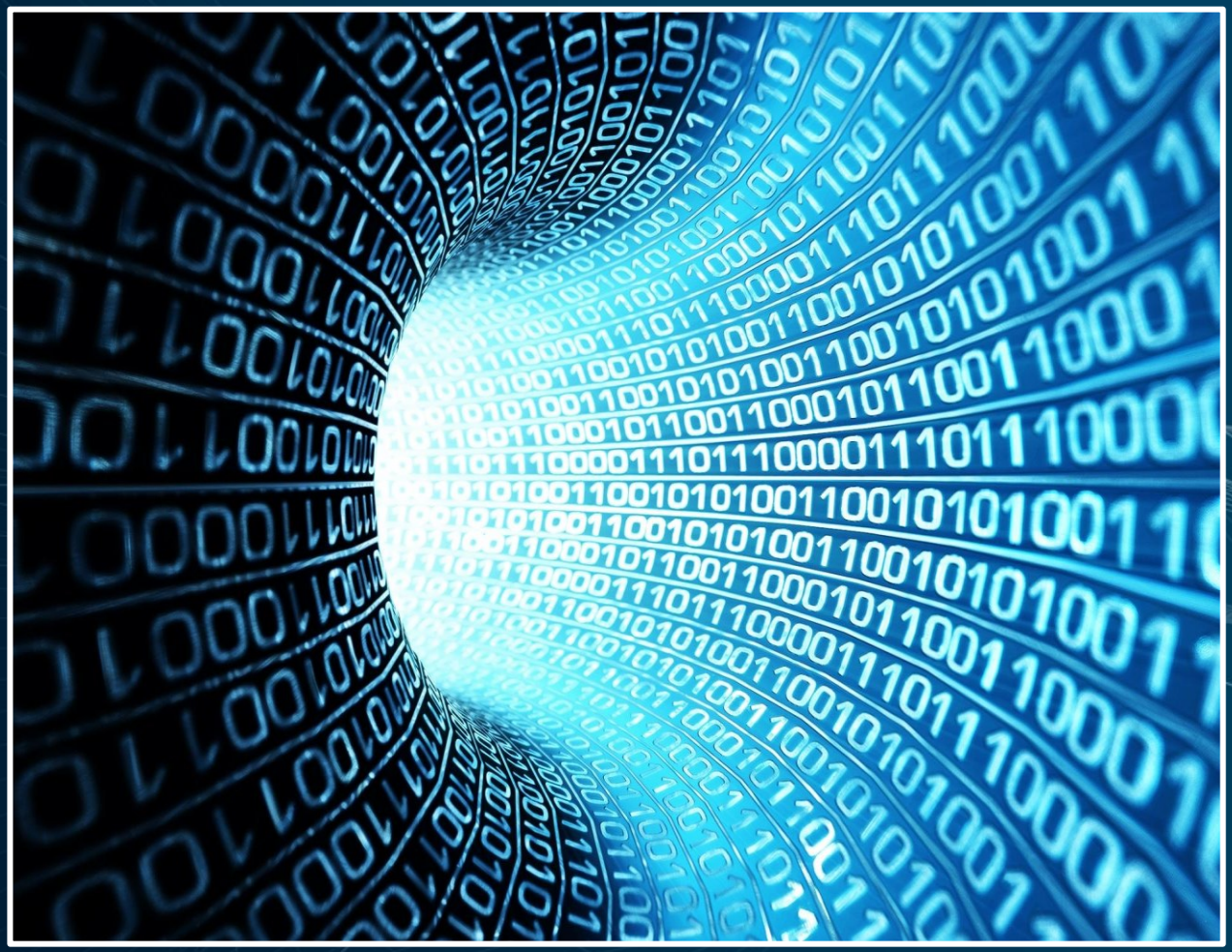


* *Treatments come from optimization (objectives, constraints)*

\+ *Treatments from tree-aware optimization (objective, constraints + tree criteria)*

T *Decision Tree Template (palatable tree criteria)*

- **Granularity criteria** – specifies the decision keys and binning for tree splits
- **Level criteria** – specifies an ordering for decision keys when constructing a new tree
- **Eligibility criteria** – specifies which treatments are allowed along specific tree branches
- **Consistency criteria** – specifies how treatment actions must change in parallel with other variables

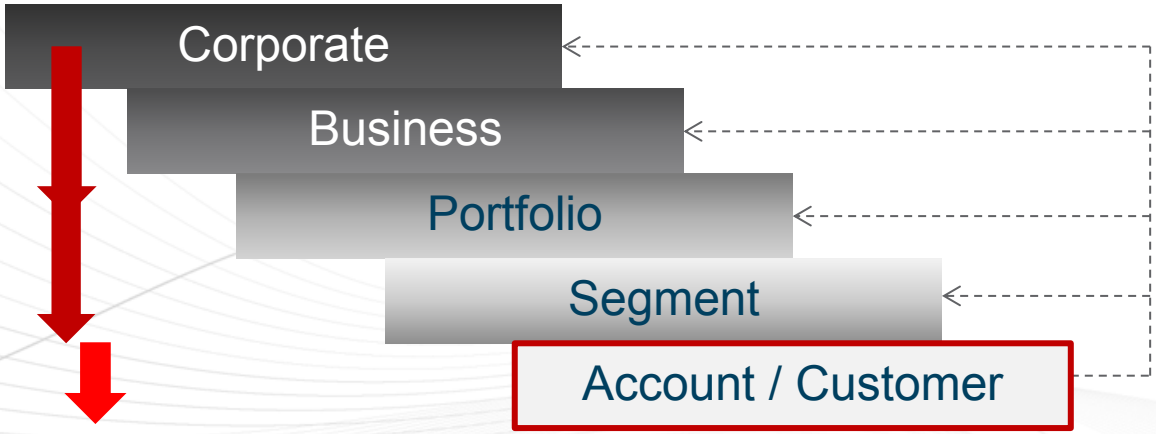


Complex Problems

- Capital Management
- Customer Level
- Ultra Large Scale

Decision Modelling & Optimisation
for Capital Allocation & Management

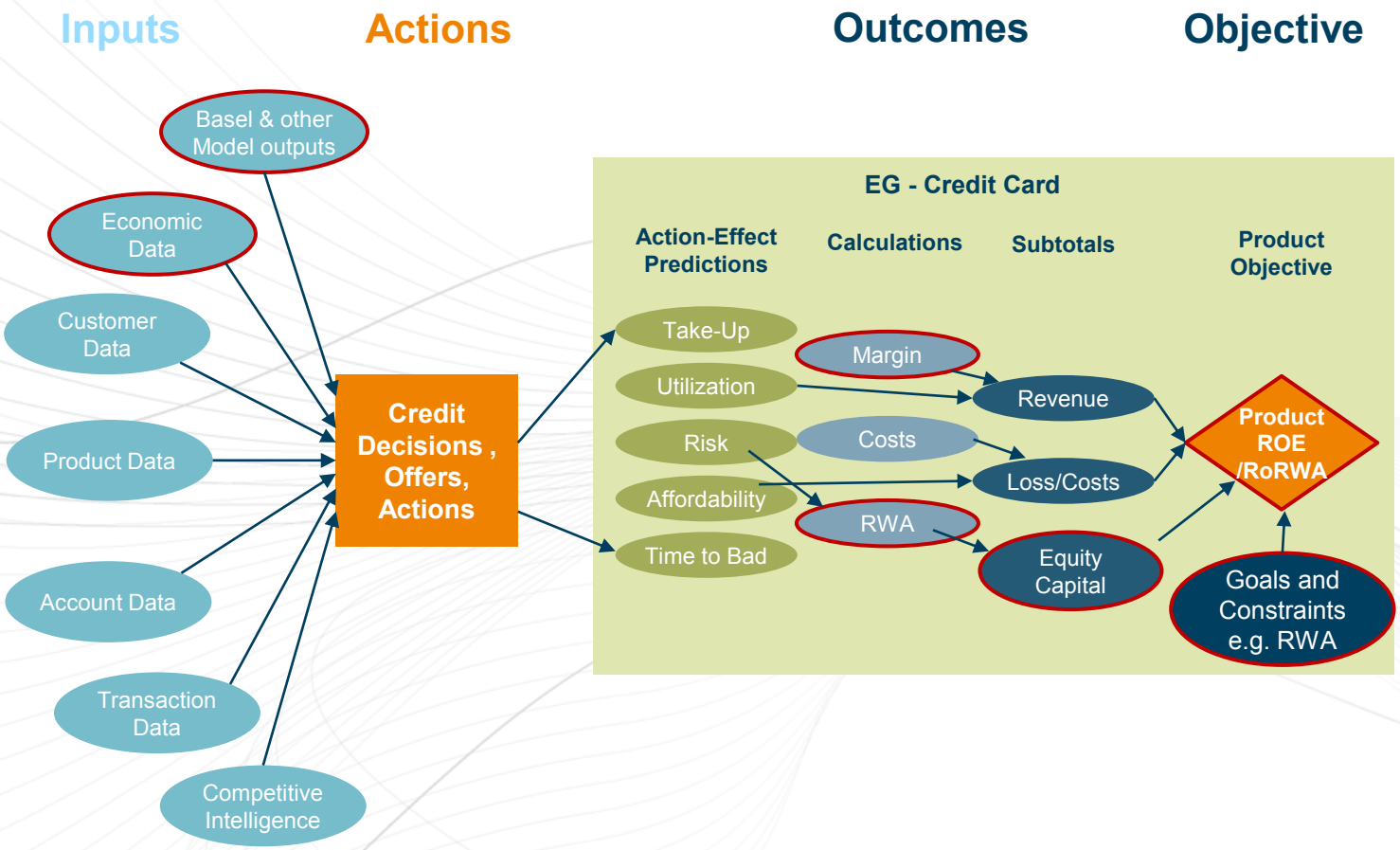
- **Connecting Decisions - Vertically**



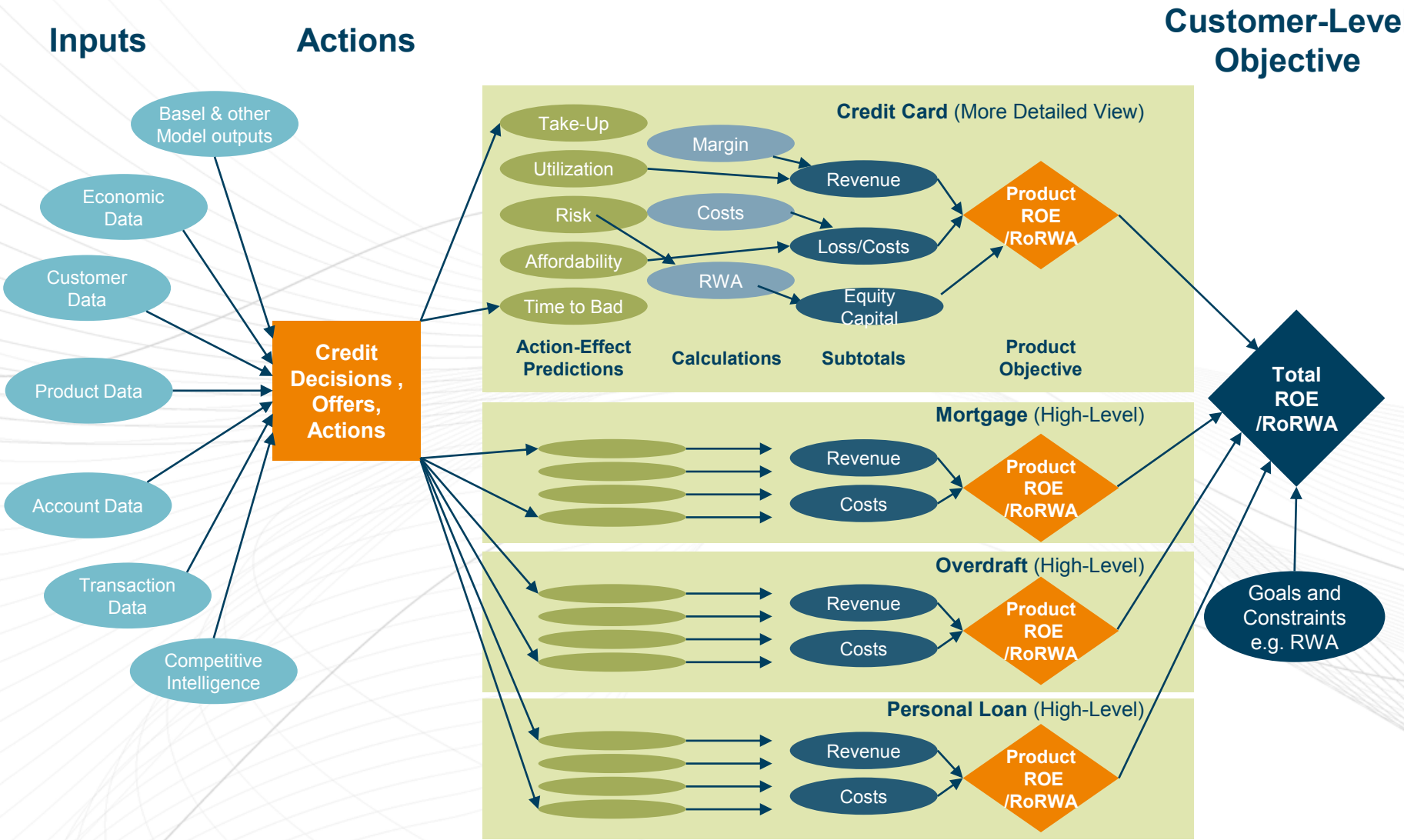
- *Execution of strategies to raise performance required:*
  - *At account / customer level*
  - *At the decision area level*

- *Decision Modelling & Optimisation allows you to makes the connection from corporate objectives to account decisions possible*

Example Decision Model Design
Capital Management for Retail Credit Portfolios

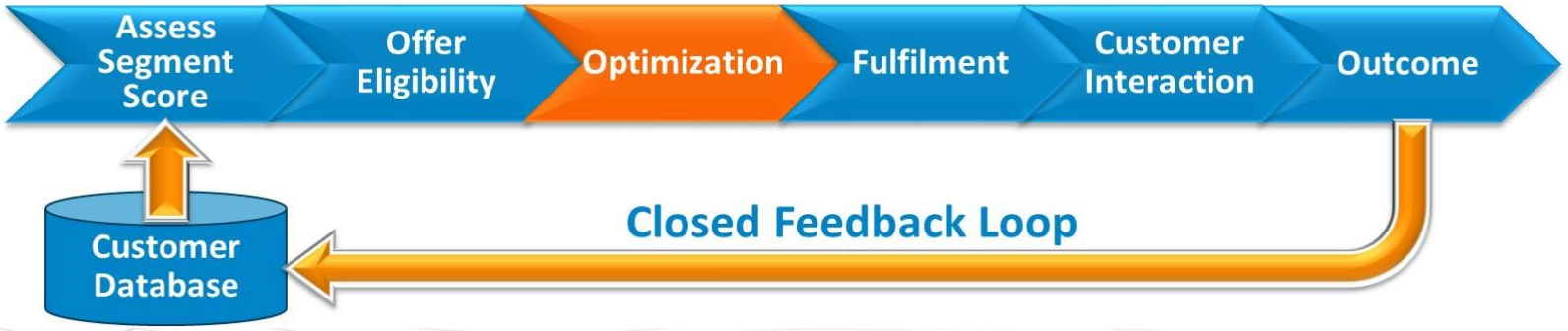


Example Decision Model Design
Customer Level Decisions

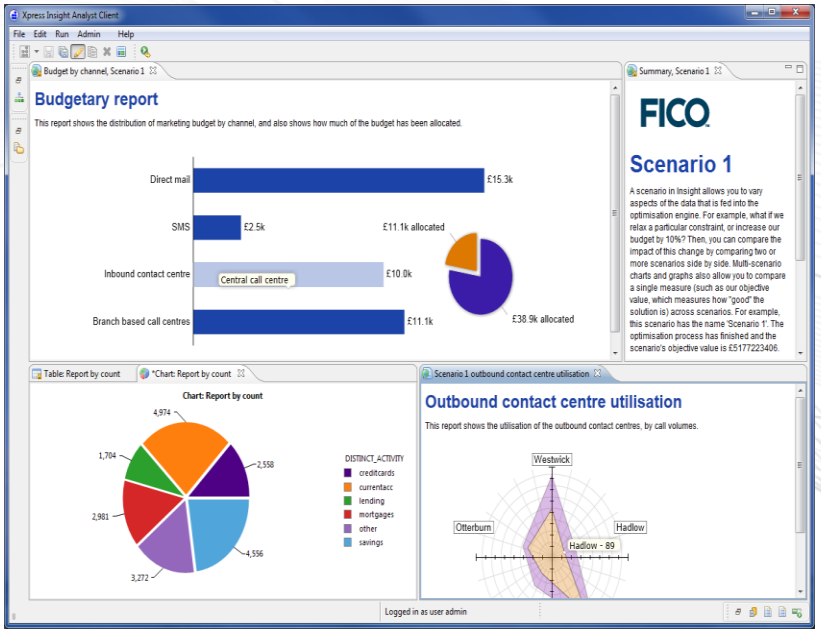


Ultra Large Scale Marketing Optimization
Case Study: European Retail Bank

Optimize possible interactions (from a pool of 000's of possibles) per customer for tens of millions customers every night.



- Subject to, for example:
  - restrictions on the number of overall interactions per customer and by channel;
  - the consistency of messages by channel; for example, a customer should not receive a lending message via Direct Mail and a savings message online;
  - the resources available to service the selected interactions; for example the number staff available to make outbound calls in a branch; and
  - Budgets and constraints by channel, region and overall.



FICO Decision Modelling & Optimization Solutions

Make optimal decisions for improved business performance, in any industry or business function

Better, faster, more consistent decisions

Identify the best actions (decisions) for achieving your business goals, while balancing competing objectives.

Protect against regulatory and economic shifts

Bring accuracy and consistency to every decision, and account for predicted economic changes in your models.

Gain competitive advantage and increase loyalty

Increase the output of your resources while gaining loyalty through consistent, customer-focused treatments.

Reduce time-to-market and increase precision

Deliver solutions quickly that address business problems and rapidly show ROI; test and learn to drive future successes.

www.fico.com

THANK YOU

Neill Crossley
Principal Consultant
FICO

neillcrossley@fico.com

+44 (0)121 781 4801

Credit Scoring and Credit Control XIII
August 28-30, 2013