Optimal Pricing: Integrating Costs and Customer Behavior

**A presentation for 2011 CAS Special Interest Seminar
In Focus: Cutting Edge Tools for Pricing and Underwriting
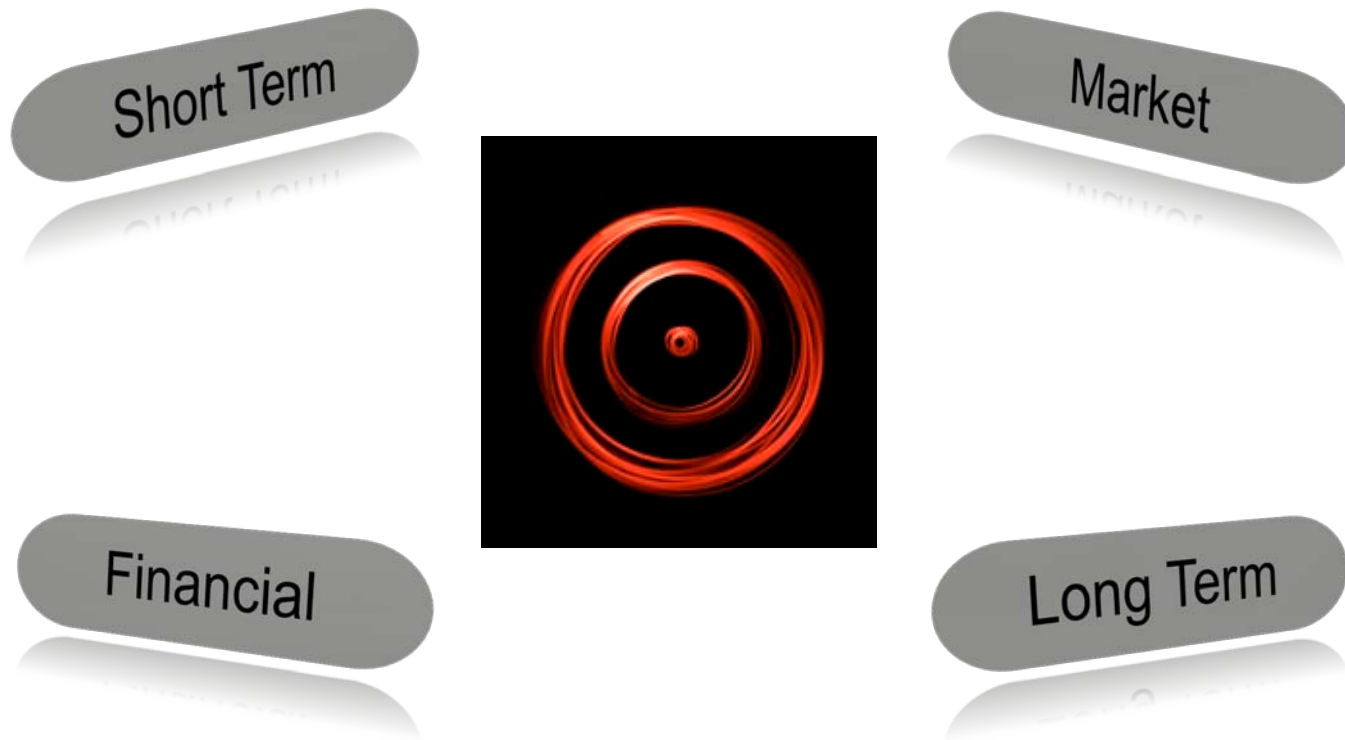by Claudine Modlin**

October 3, 2011

TOWERS WATSON

Agenda

- Background

- Technical Modeling

- Scenario Analysis

- Price Optimization

- Rating Algorithms

- Conclusion

Background

- Price is a key lever of performance
- Pricing should support corporate goals and overall business strategy

Background

Current pricing abilities

- Pricing performance scorecard for the insurance industry

Task	Ability
Aggregate loss costs	🟢
Granular loss costs	🟢
Price competitive position	🟡
Regulatory challenges	🟡
Policyholder reaction to price	🔴
Bringing it all together	🔴

🟢 Ready
🟡 Somewhat ready
🔴 Not ready

What is price optimization?
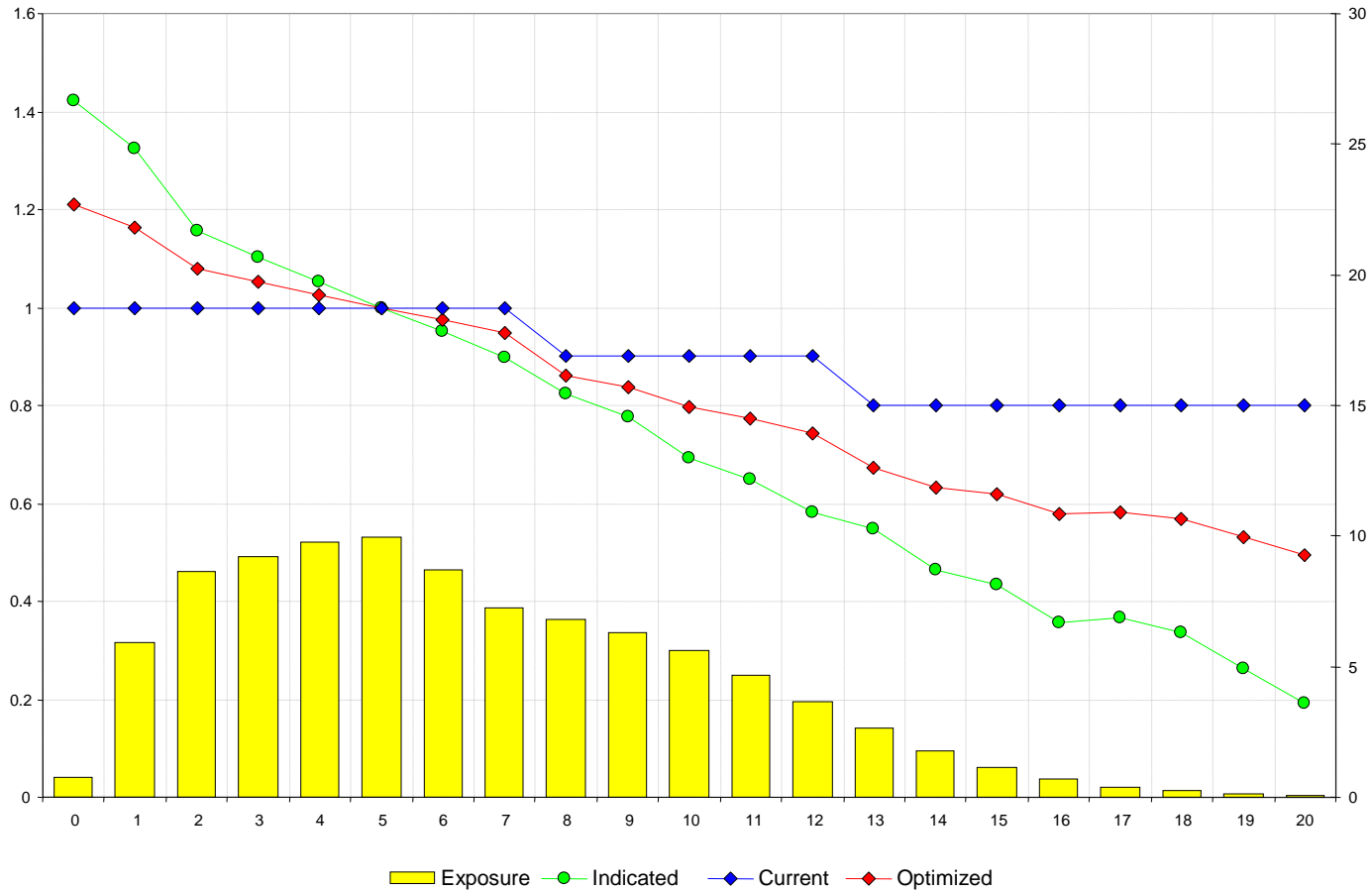
Background

- Price elasticity models dramatically improve understanding of policyholder behavior toward price

- Price optimization models systematically pull all relevant information together to determine the best prices to support company goals

Background

What is price optimization?
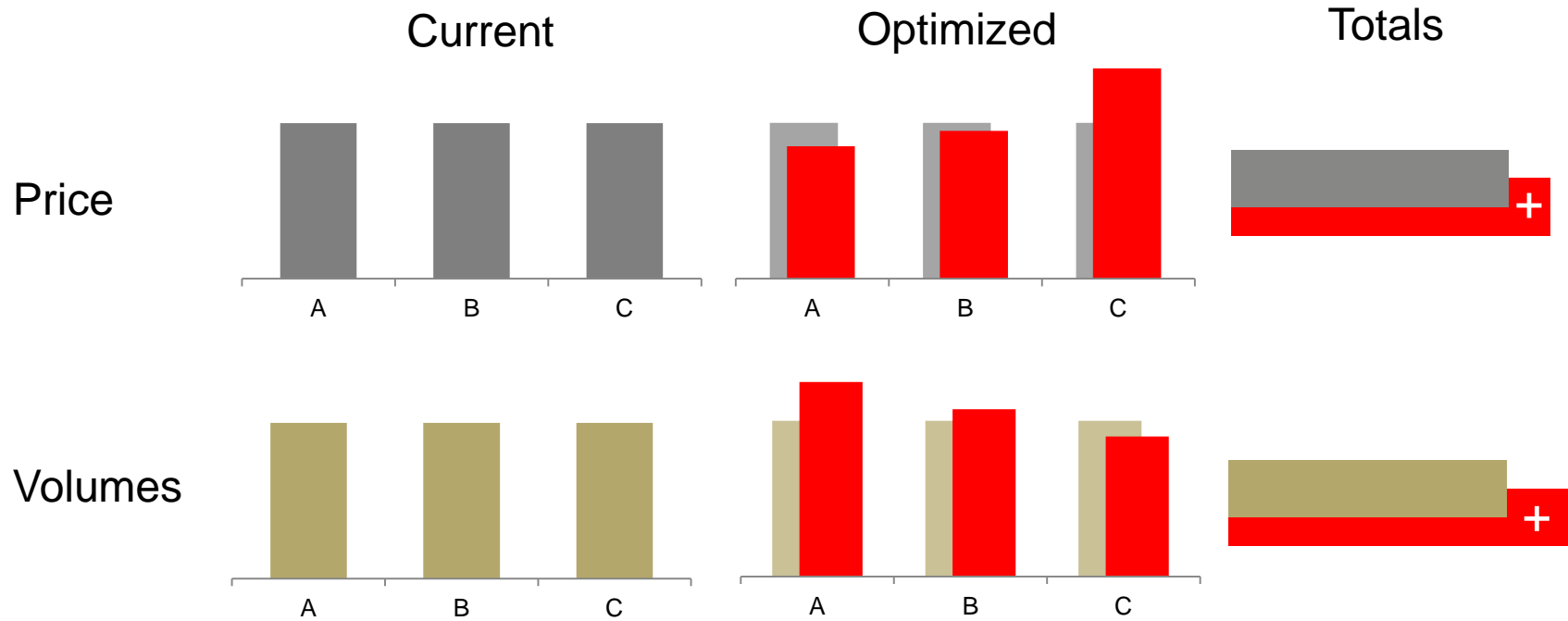
- Selecting each rate within the range of actuarially sound rates that will best contribute to the company's goals

Background

Why optimize?

Commercial Reality

- Universal desire for profitable growth
- Increasing acquisition costs
- Data, computing power and statistical tools make optimization feasible
- Scarcity of technical pricing resources
- Competitors are optimizing prices

Optimization Benefit

- Both profit and volumes improved
- Maximize value from current portfolio and new business flow
- Increase effectiveness of marketing messages
- Align strategy across multiple new business distribution channels
- Optimally moderate renewal increases
- Counter potential loss of competitiveness

The Impact of Good Pricing on Performance

Towers Watson case studies

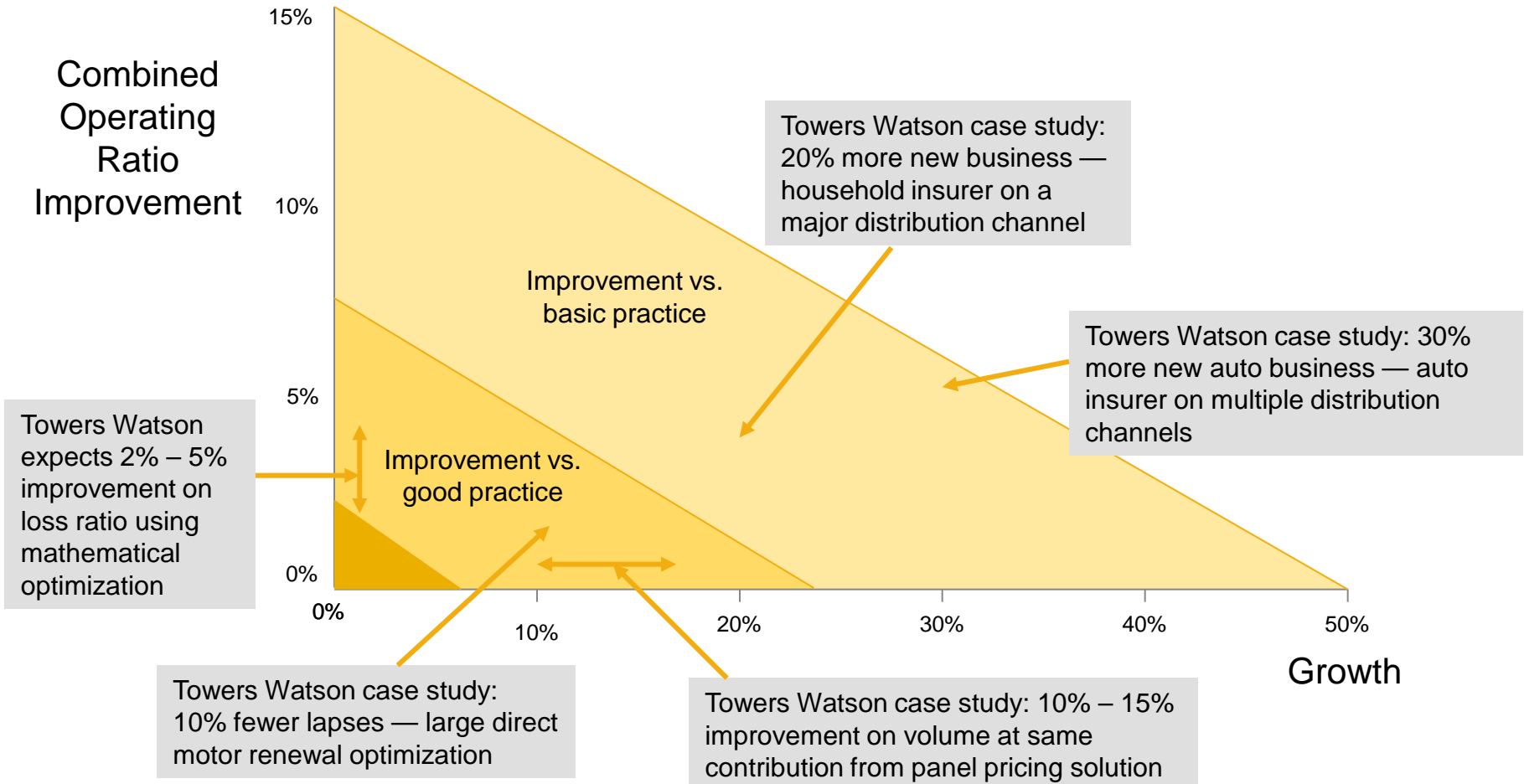**Combined Operating Ratio Improvement** (y-axis: 0% to 15%)

Growth (x-axis: 0% to 50%)

Improvement vs. basic practice

Improvement vs. good practice

Towers Watson case study: 20% more new business — household insurer on a major distribution channel

Towers Watson case study: 30% more new auto business — auto insurer on multiple distribution channels

Towers Watson expects 2% – 5% improvement on loss ratio using mathematical optimization

Towers Watson case study: 10% fewer lapses — large direct motor renewal optimization

Towers Watson case study: 10% – 15% improvement on volume at same contribution from panel pricing solution

Pricing Process With Optimization

Basic Optimization Process

Technical Models

Scenario Analysis
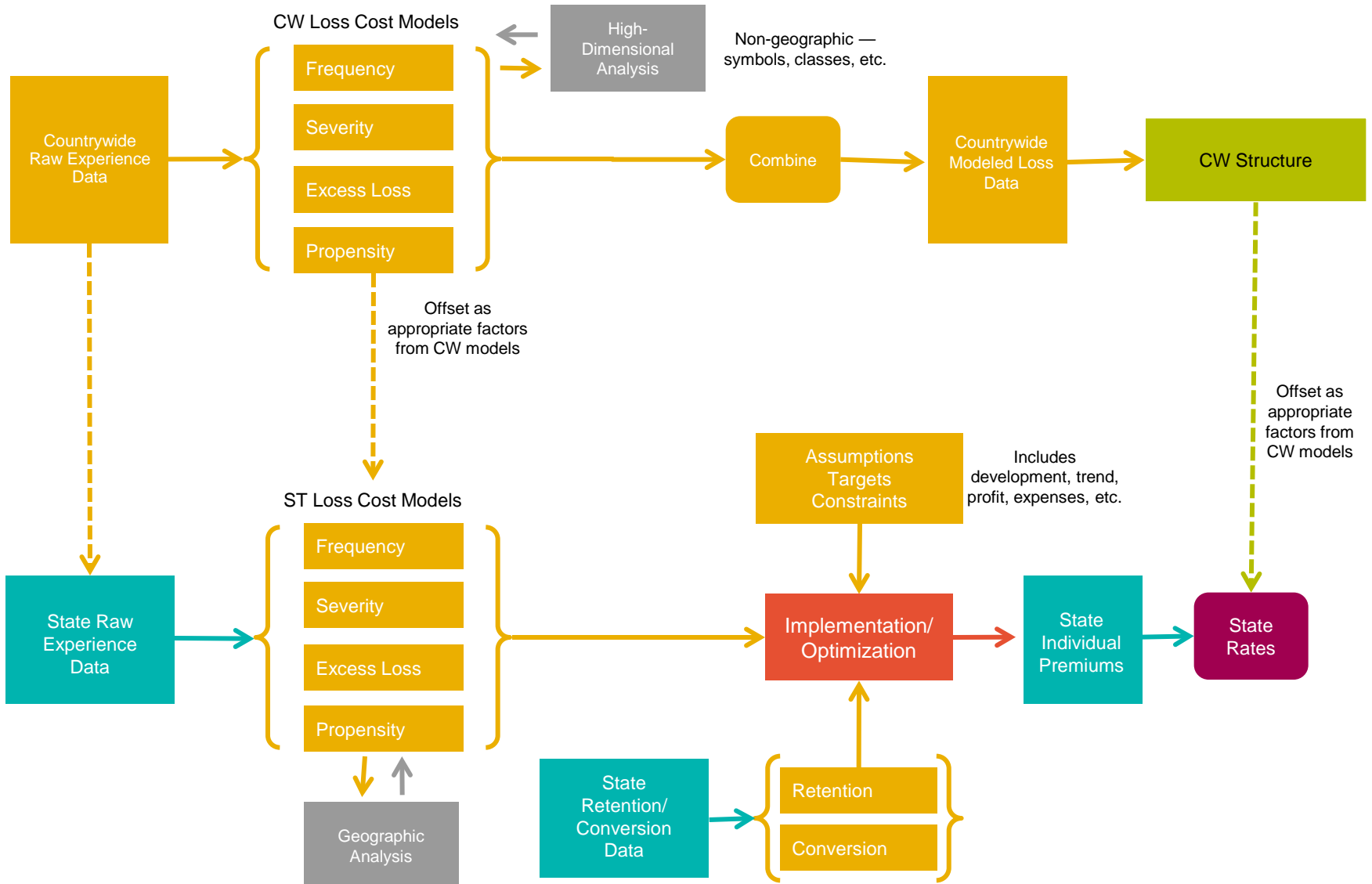
Optimization   **Rates**   **Results**
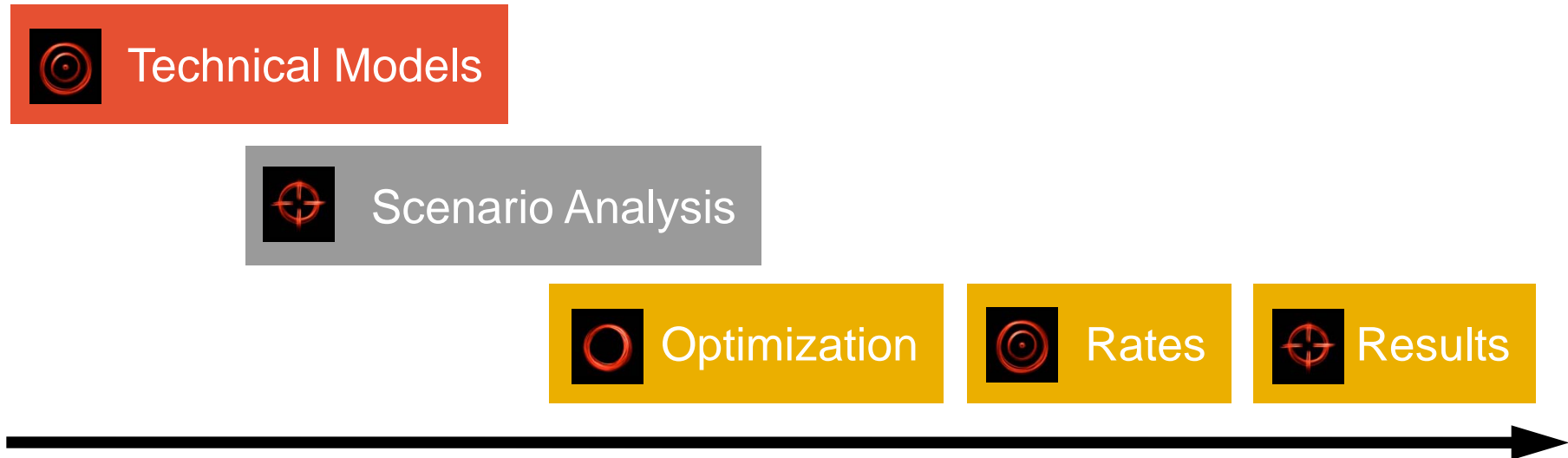
- Proven approach to deliver incremental benefits

Basic Optimization Process

● Technical models are the cornerstone of the optimization process

Technical Inputs

High-quality technical inputs

- Loss cost and expense models
  - Up to date, sufficiently complex
  - Accurate geographical and vehicle classification factors
- Demand models
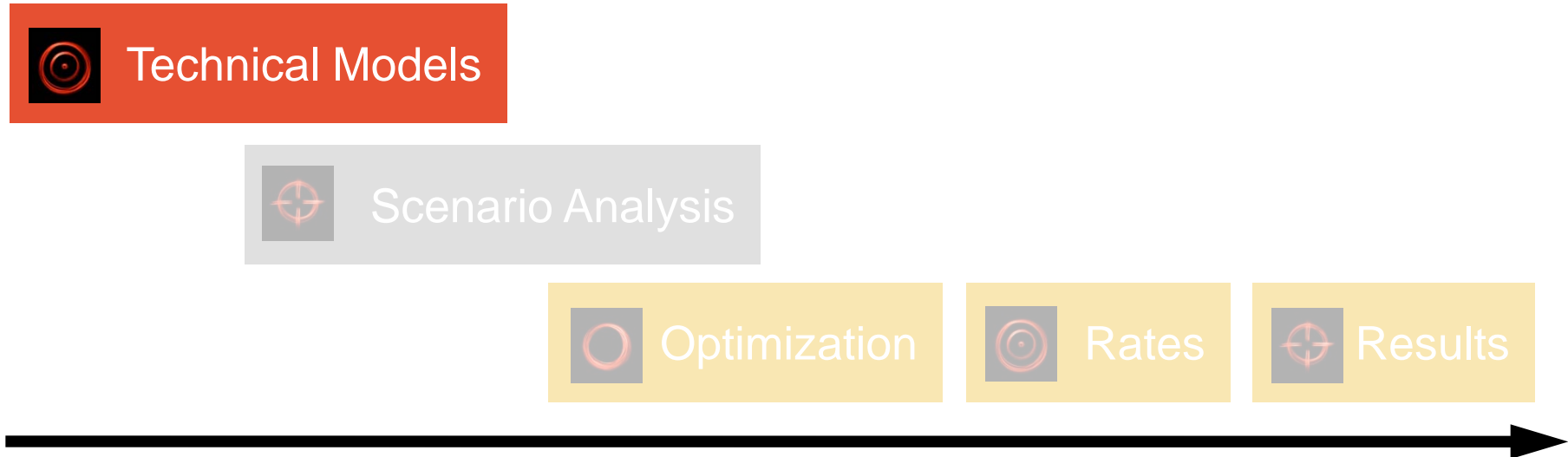 - Suitable range of historic rate changes
  - Competitive premium data
  - Customer factors to capture segment differences
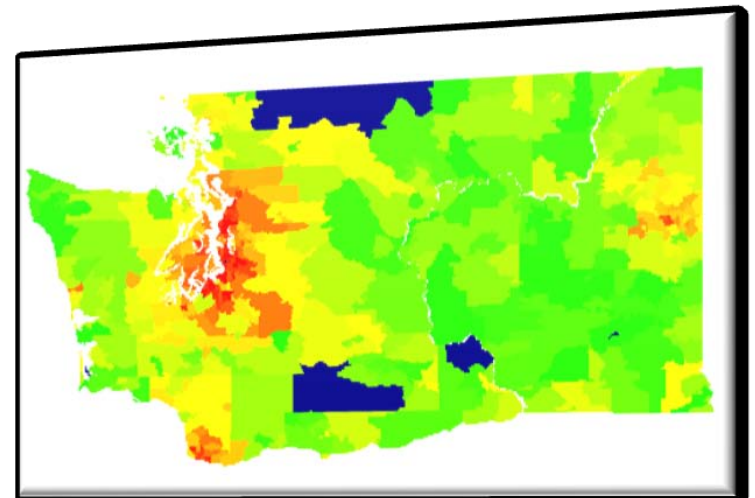
Loss Cost Models	Expense Models	Demand Models

Technical Inputs

Loss cost models and expense loads

- Profit contribution elements
  - Loss costs
  - Expense loads
- Customer factors
  - Risk is overestimating profit in uncompetitive segments

- Classification factors (ZIP codes, make/model) are key considerations
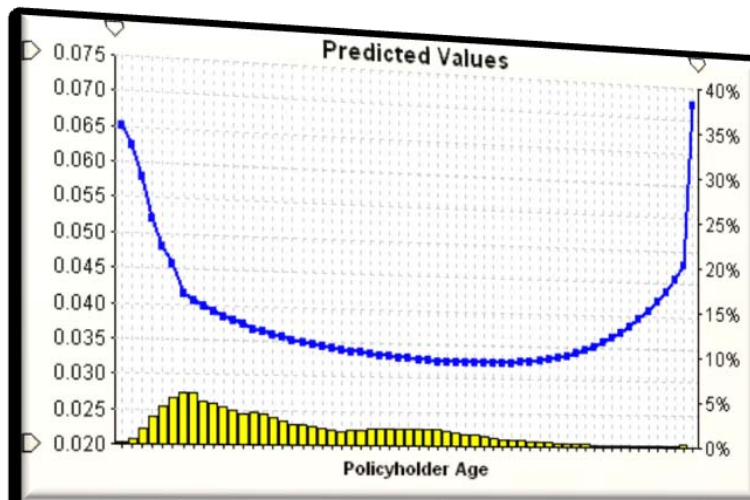
Technical Inputs

The human decision-making process

- Customer attributes and attitudes

- Company-triggered changes

- Customer-triggered changes

- External influences

- Key elasticity variables

  - Premium/premium change

    — Subtle price testing can be used to enrich data

  - Competitive ratio
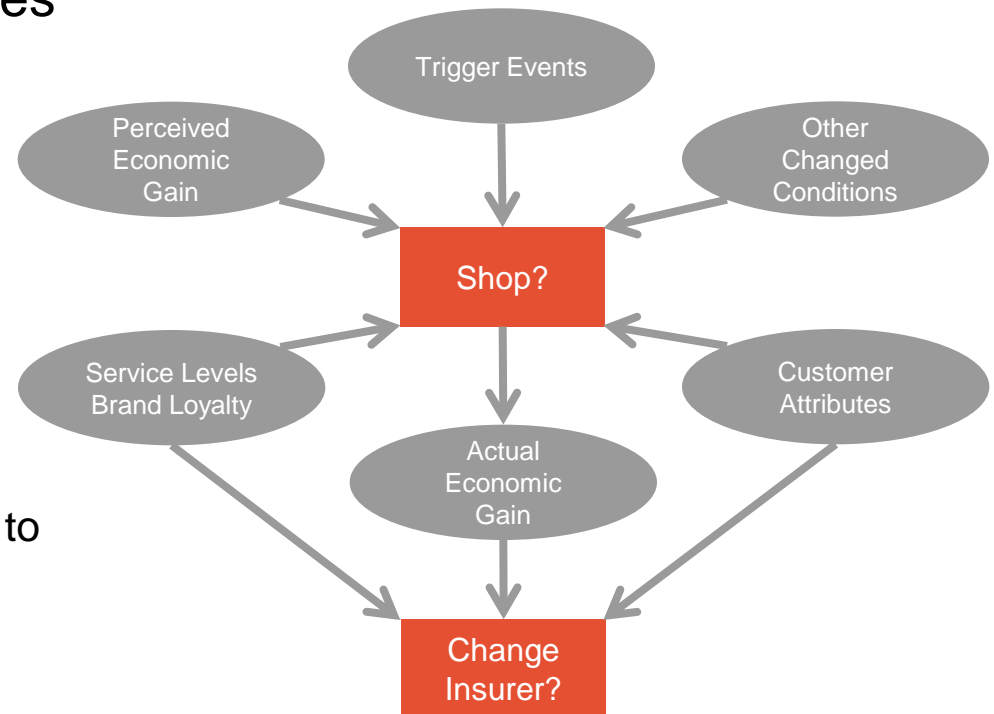
Modeling elasticity vs demand

- Y-variate still "did they buy, yes/no"

- Focus on price related explanatory variables different

- Can re-express as elasticity by wobbling price explanatory variables after fitting model

Elasticity by Age
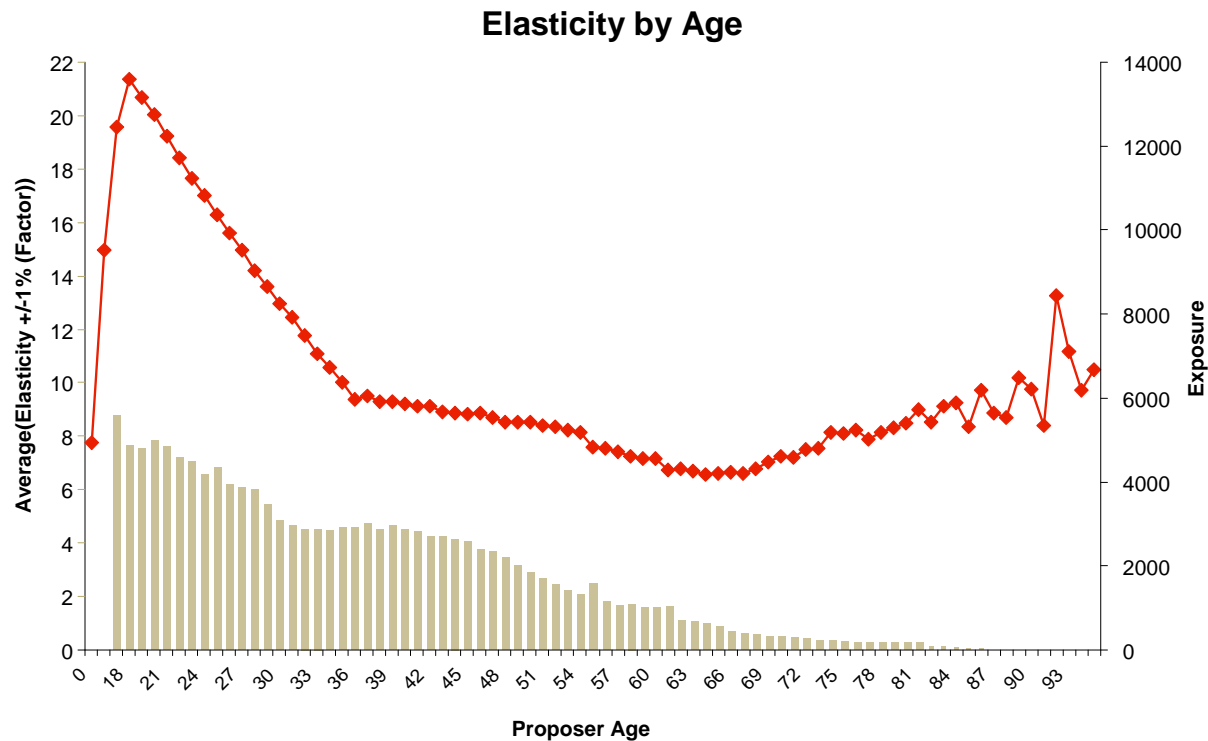
Price trials

- In deregulated markets, ideally vary random sample of quotes on an ongoing basis

- In regulated markets, other standard rate changes need to act as a proxy

- Best to decorrelate from other factors as much as possible

- Geographical or vehicle reclassification can yield valuable elasticity understanding

- But, you have what you have!

- If range is limited, scope can be limited

New Business Price $
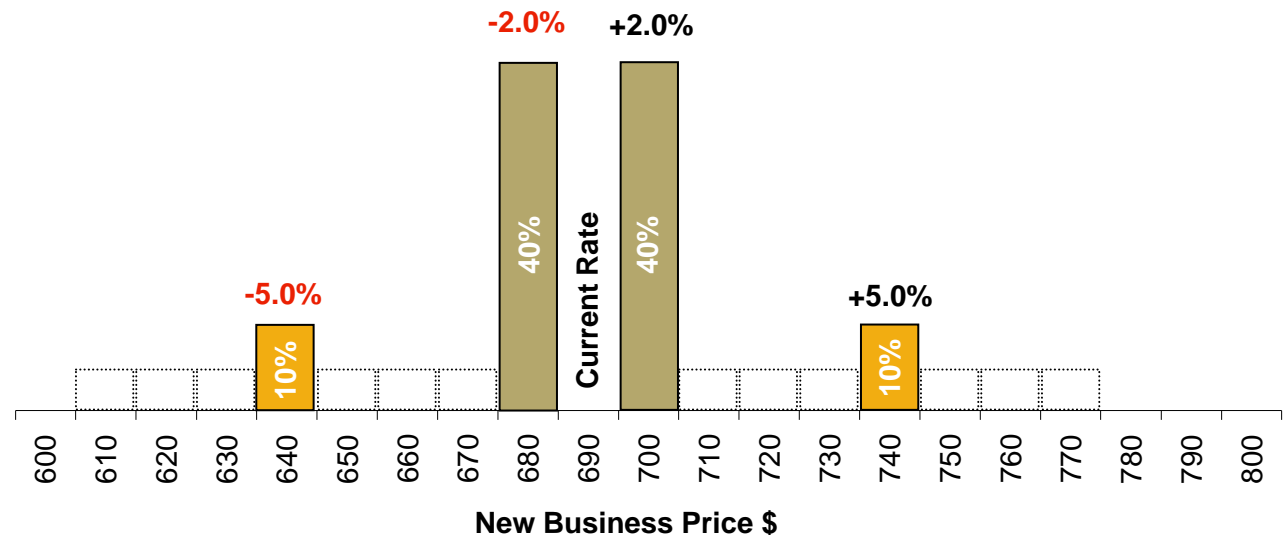
Technical Inputs

Elasticity models

Classification and Regression Trees	Generalized Linear Models	Generalized Nonlinear Models

• Interpolate missing data
 	
• Identify initial main effects
 	
• Identify key segments for models
 	
• Identify complex interactions
	• Parameterizes model structure
	
	• Complex interaction strategies
	
	• Issues
	
	   • **Possible negative elasticity**
		• Interacts price factors with all non-price factors
		
		• Nonlinear element forces positive elasticity
		
		• Issues
		
		   • **Tendency to overfit**
		
		   • **Ignores real negative elasticity**

• Modeling requires flexibility in choosing the right strategy for the right data set

Technical Inputs

Different strategies required for new and renewal policies

Renewals/Retention

- Elasticity variables
  - Premium change
  - Competitive ratio
- Price tests implicit in data
- Segmental GLMs
  - Localized models for segments with materially different response rates
  - Multiple interactions with elasticity variables

New Business/Conversion

- Elasticity Variables
  - Quoted premium
  - Competitive ratio
  - Price test perturbation
- Competitive ratios explicit
- Price perturbation explicit
  - Complex model structure required
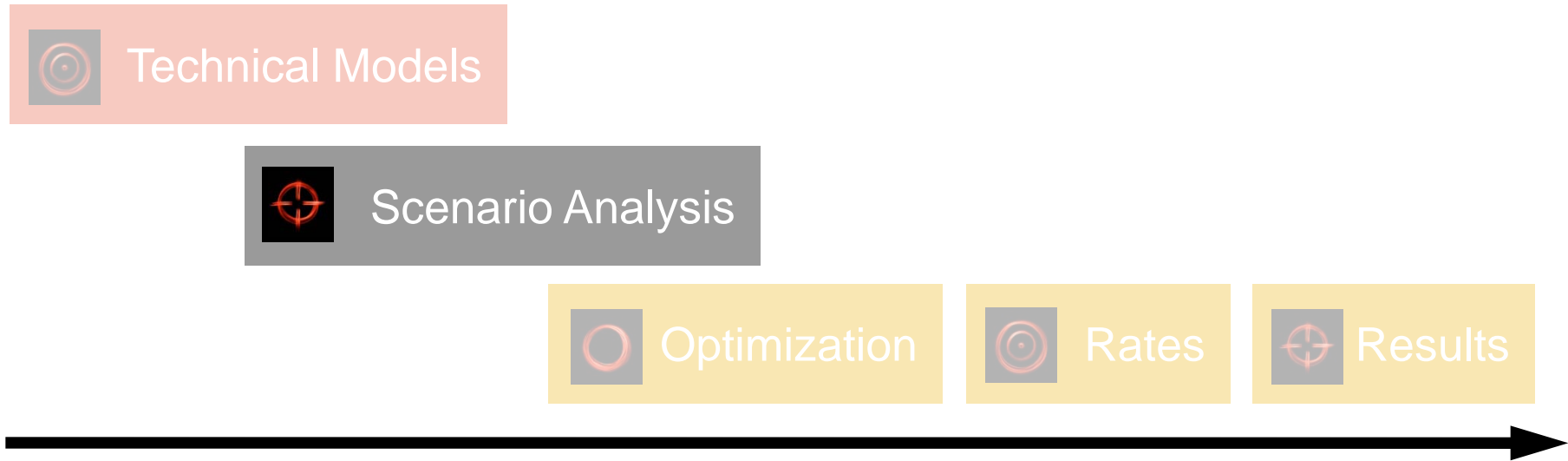 - GNMs used to enforce positive elasticity

Technical Inputs

- Non price parameters compiled into a customer score interacted with competitive ratio
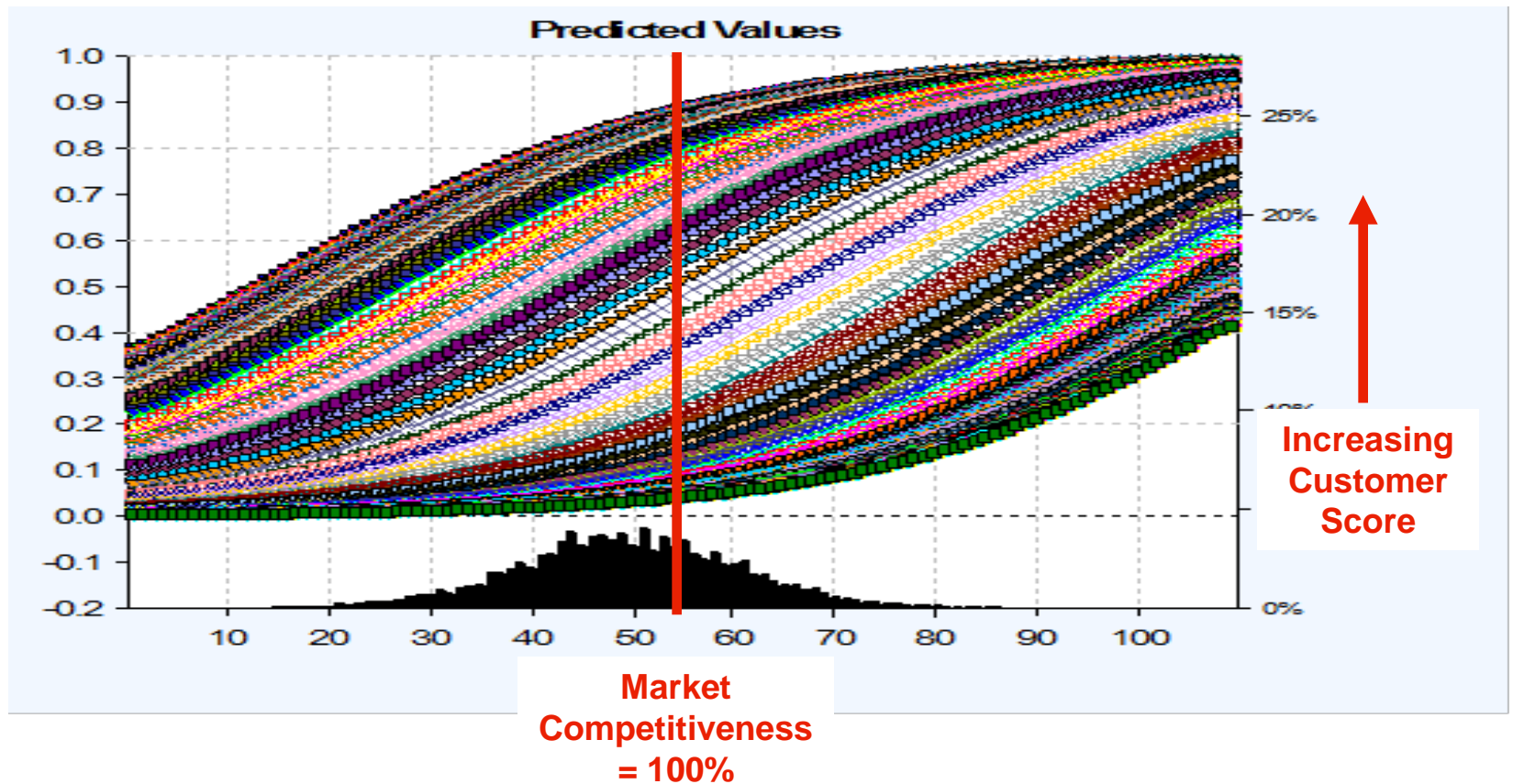
Basic Optimization Process

Create several scenarios to understand how the technical models fit together
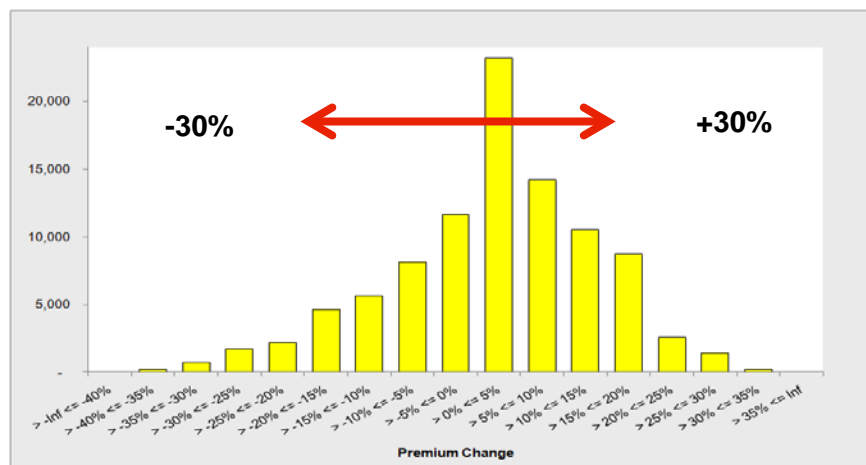
Scenario Analysis — Revenue Neutrality

Standard analysis

- Overall effect on premium is revenue-neutral
  - Overall effect on premium volume is revenue-neutral
  - Individual policies could still see large swings in rate

$$\frac{\sum\limits_{CurrentPolicies} ProposedPremium}{\sum\limits_{CurrentPolicies} CurrentPremium} = 1.000$$
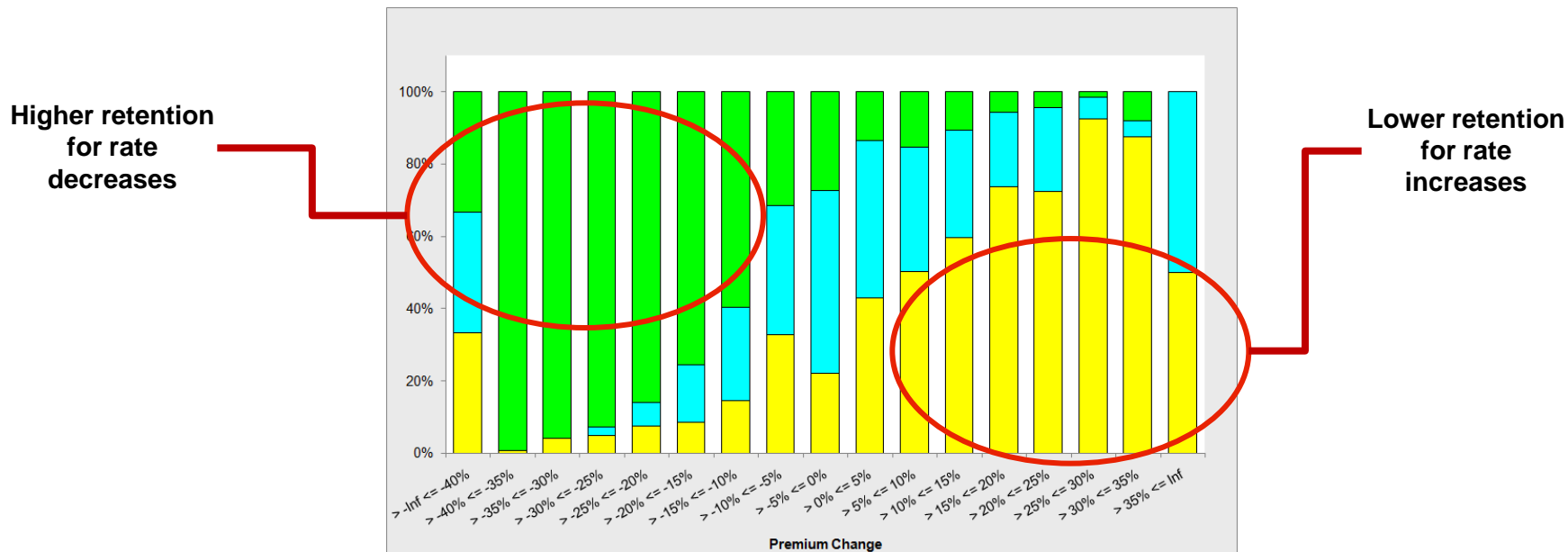

- Disadvantages
  - Assumes renewals accept new price *or*
  - Assumes new business will offset the additional renewals

Scenario Analysis — Revenue Neutrality

Enhanced analysis

- Need to reflect retention and conversion effects

$$\frac{\sum\limits_{CurrentPolicies} ProposedPremium \times Retention + \sum\limits_{Quotes} ProposedPremium \times Conversion}{\sum\limits_{CurrentPolicies} CurrentPremium} = 1.000$$

Higher retention for rate decreases

Lower retention for rate increases

Premium Change

Scenario Analysis

Create multiple rate scenarios, and study the impact on company objectives

Scenario	Rate Change	Proposed Combined Ratio	Expected Renewal	Expected Combined Ratio
No change	0.0%	88.9	82.4%	90.1
Current rates + 5%	5.0%	84.7	80.0%	86.0
Indications with 6.5% profit	5.8%	84.0	79.6%	84.0
Selections* with 6.5% profit	6.4%	83.6	79.4%	83.5

* Reflects alternate factors in the class plan, model year factor and territory
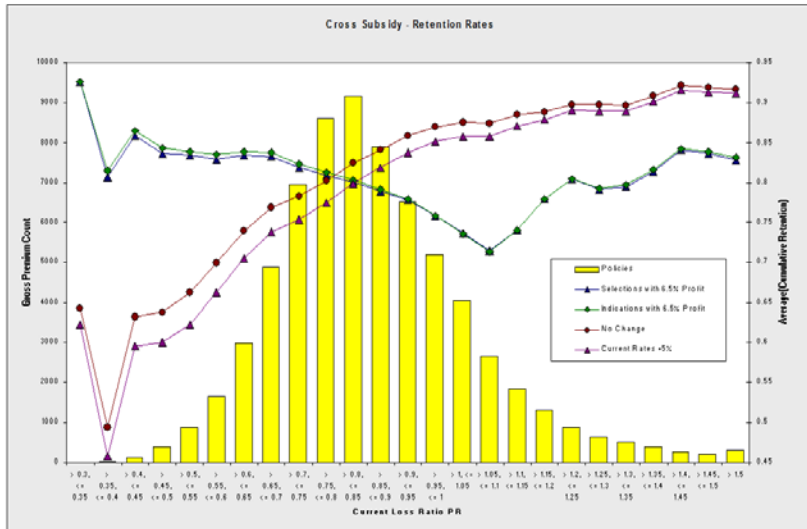
Scenario Analysis

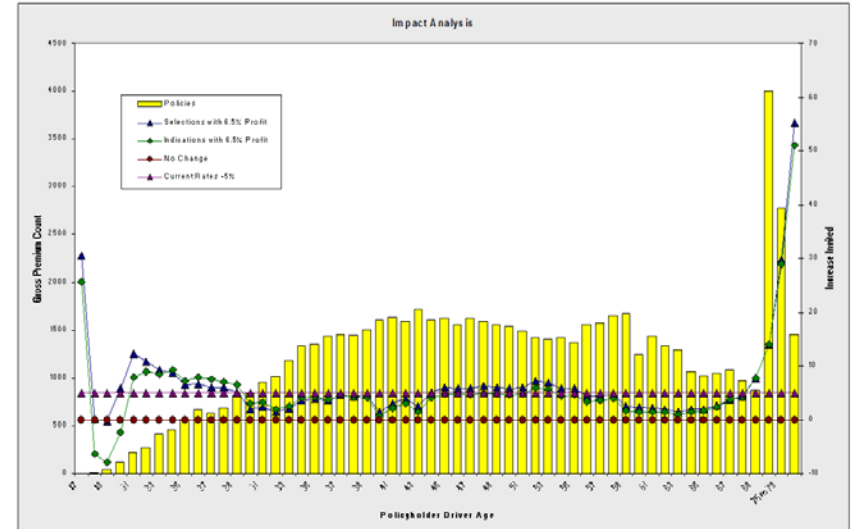## Drill down into market baskets to identify impact

Scenario
No change
Current rates + 5%
Indications with 6.5% profit
Selections with 6.5% profit

Expected retention by current combined loss ratio


Rate changes by driver age

Scenario Analysis

- Advantages
  - Quickly perform what-if scenarios
  - View impact on full array of goals with each variation in rate selection
- Limitations
  - Able to study a finite number of scenarios

Optimization takes scenario analysis to the ultimate level — systematically identifies the best scenario

Basic Optimization Process

- Mathematical quantification of trade-offs
- Search algorithm to find optimal premiums
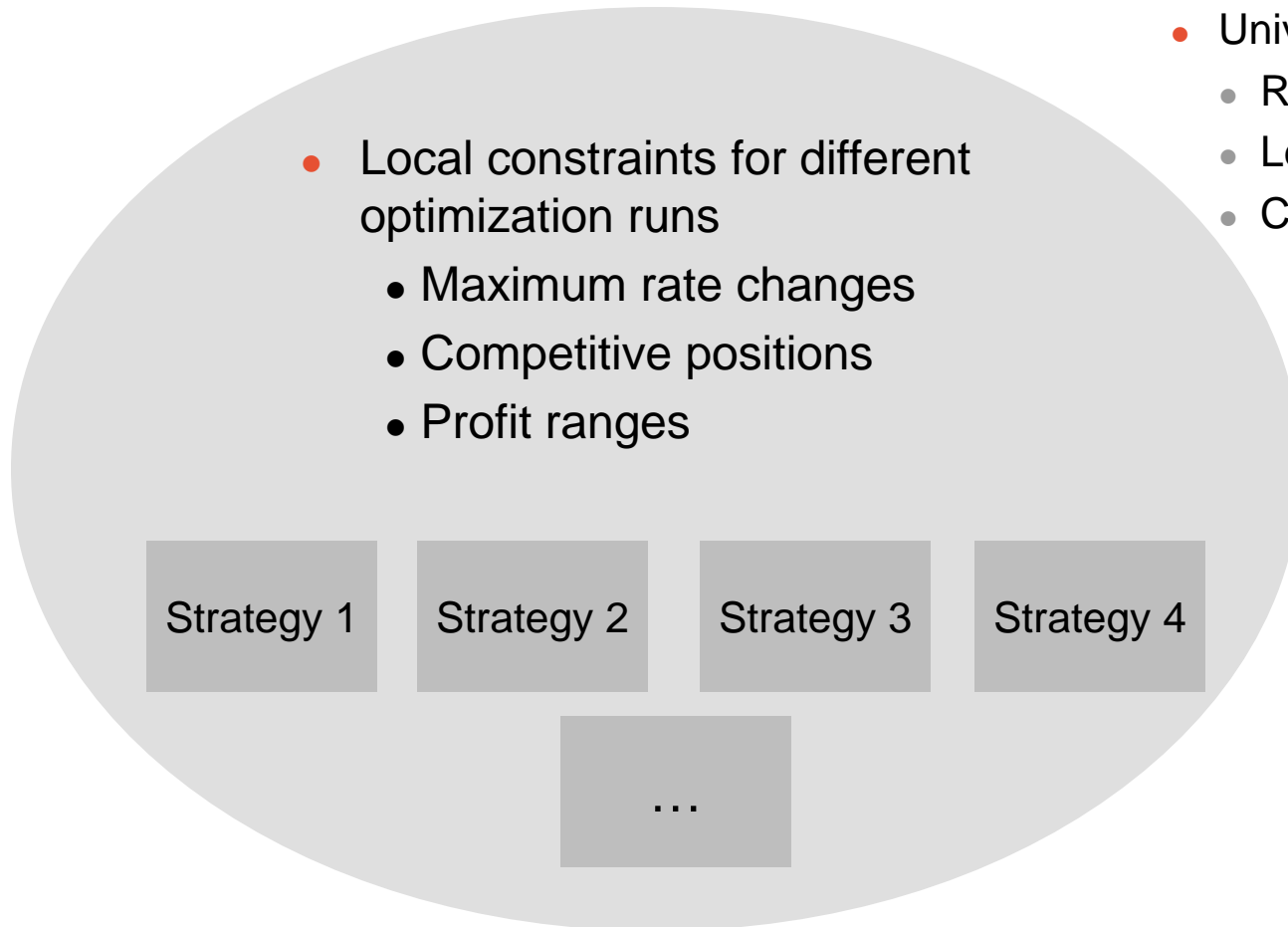
Technical Models

Scenario Analysis

Optimization   Rates   Results
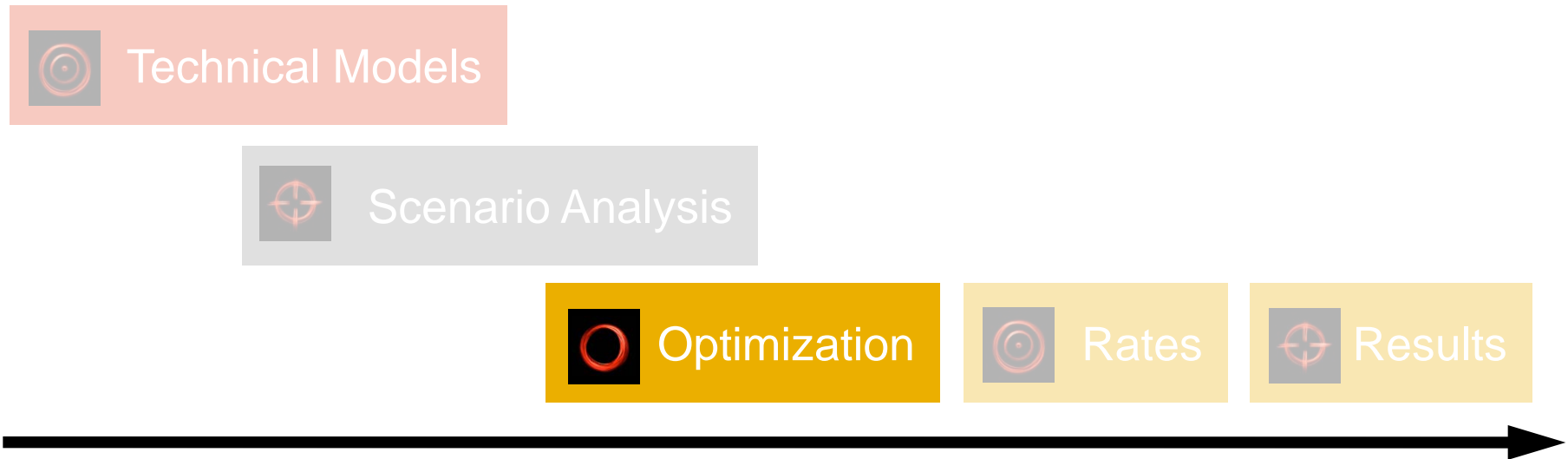
Optimization Inputs

Define the optimization problem appropriately

- What are the constraints?

- What are the optimization targets?

- What is the search mechanism?

Constraints

Wide array of constraints are reflected in the solution

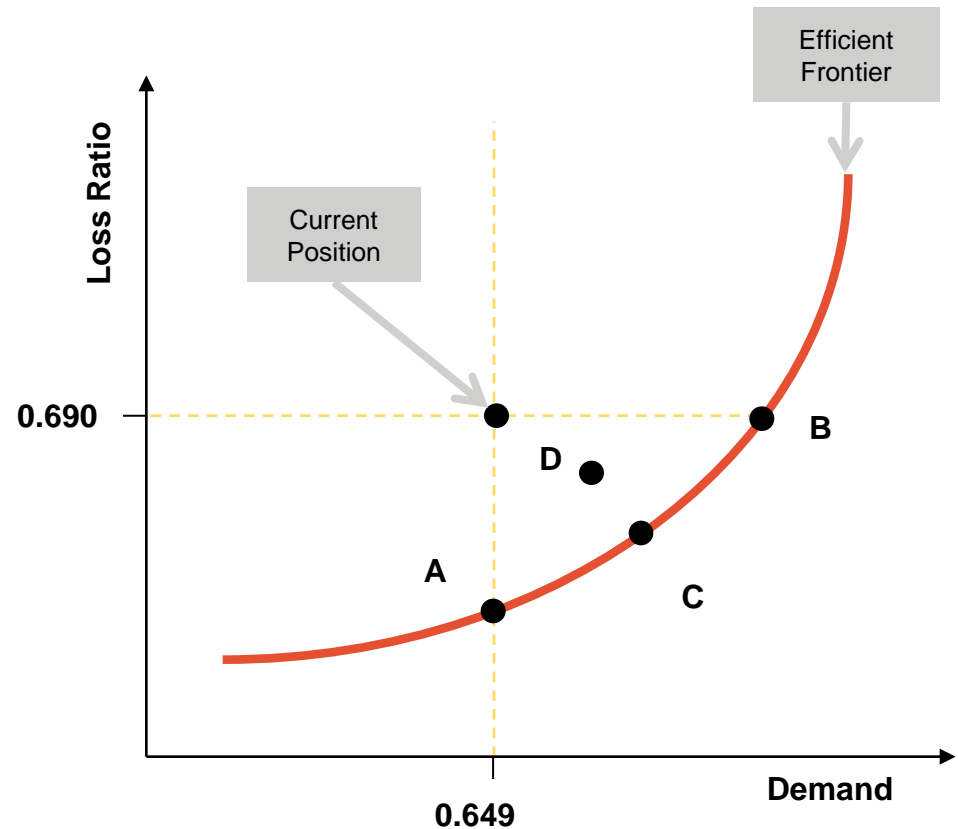- Local constraints for different optimization runs
  - Maximum rate changes
  - Competitive positions
  - Profit ranges

- Universal constraints
  - Regulatory
  - Legal
  - Corporate

Strategy 1   Strategy 2   Strategy 3   Strategy 4
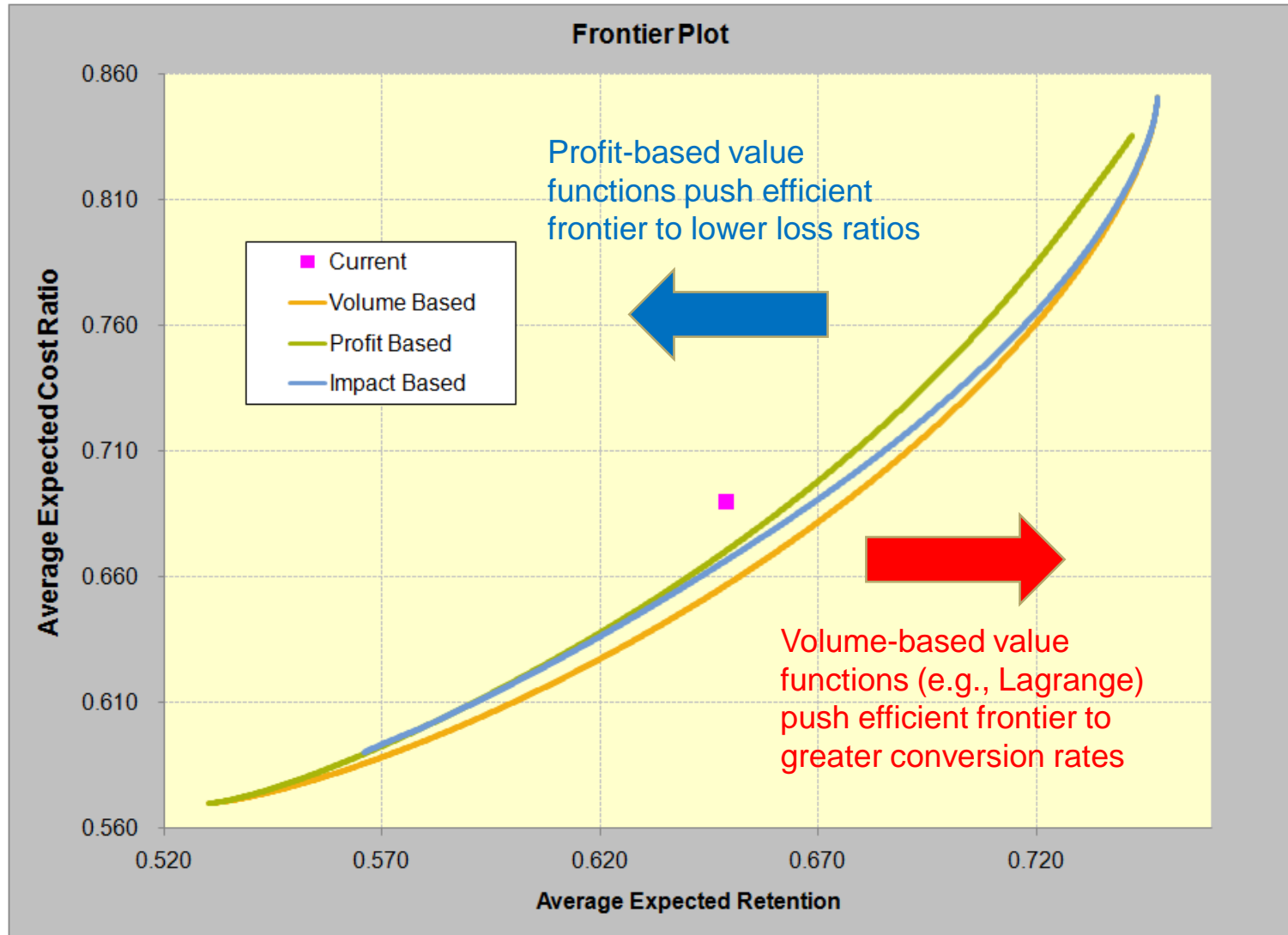
…

Balancing profit and volume

- Can optimize

  — profit for a particular volume, or

  — volume for a particular profit

  over a defined time horizon

- Try different options to understand different balances available

- Generates efficient frontier which aids understanding of target selection

Optimization Targets

- Efficient frontier

  - Maximize profits (A)

  - Maximize volume (B)

  - Increase profits and volume (C)

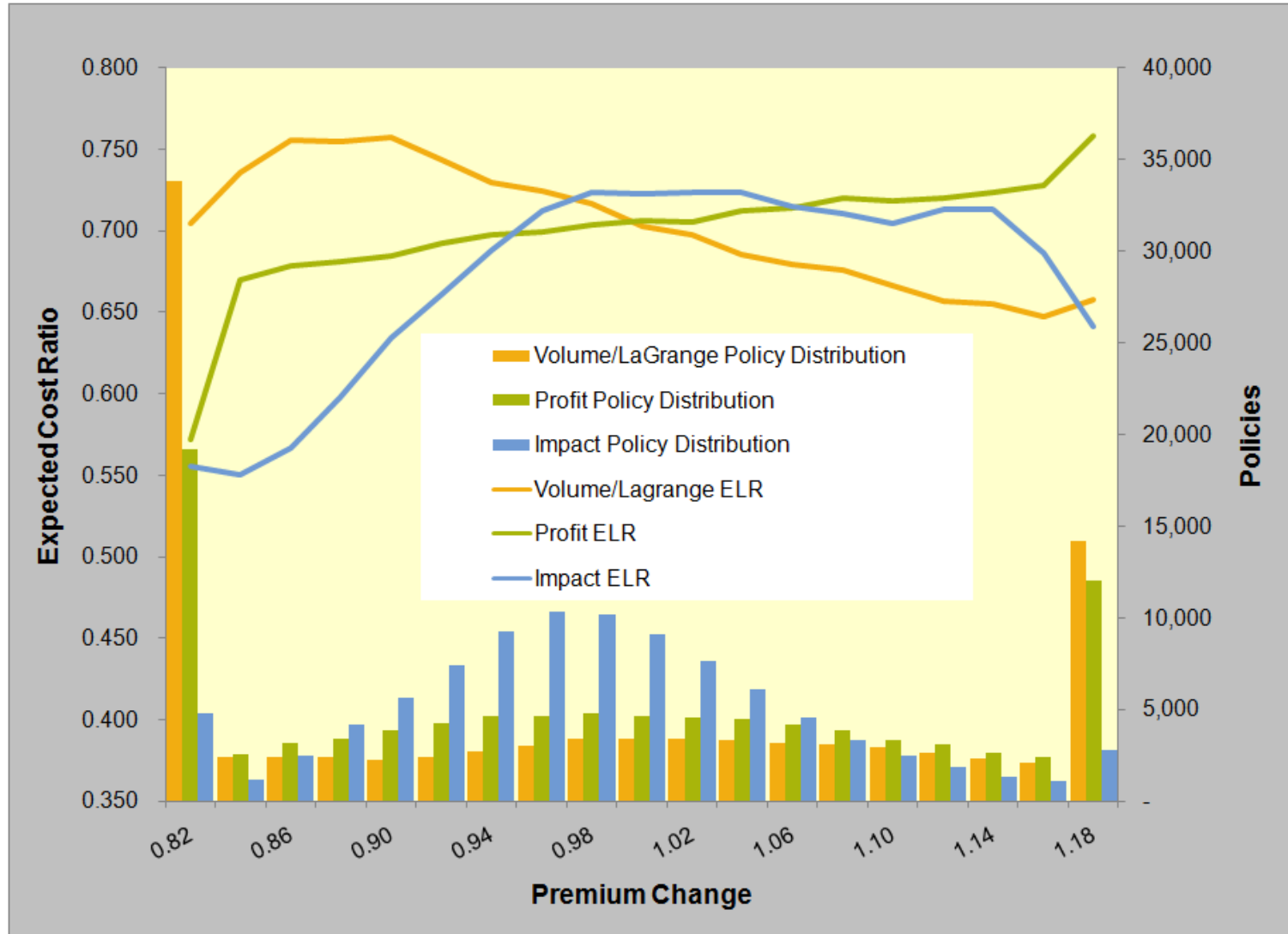 - Softer targets (e.g., business mix) (D)

Comparing Search Mechanisms

Frontier Plot

- Current
- Volume Based
- Profit Based
- Impact Based

Profit-based value functions push efficient frontier to lower loss ratios

Volume-based value functions (e.g., Lagrange) push efficient frontier to greater conversion rates

Average Expected Cost Ratio (y-axis): 0.560, 0.610, 0.660, 0.710, 0.760, 0.810, 0.860

Average Expected Retention (x-axis): 0.520, 0.570, 0.620, 0.670, 0.720
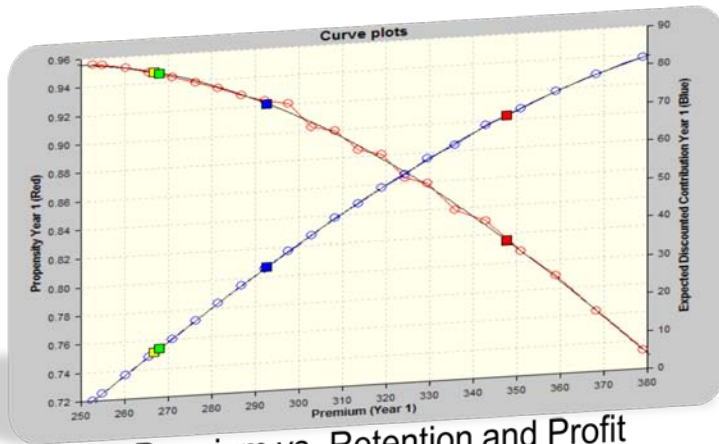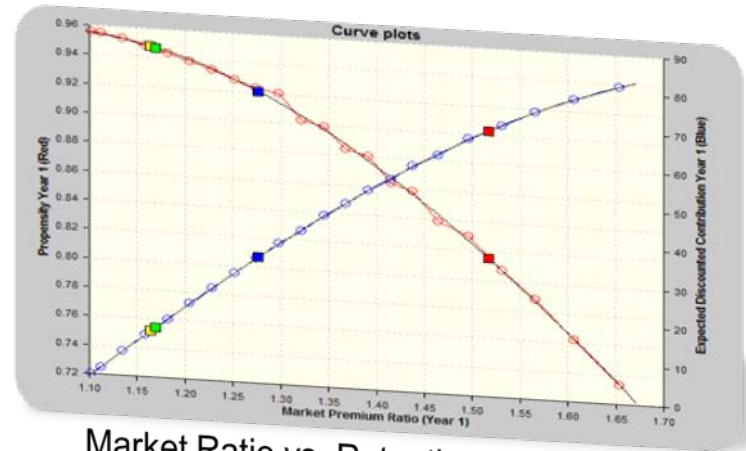
Comparing Search Mechanisms
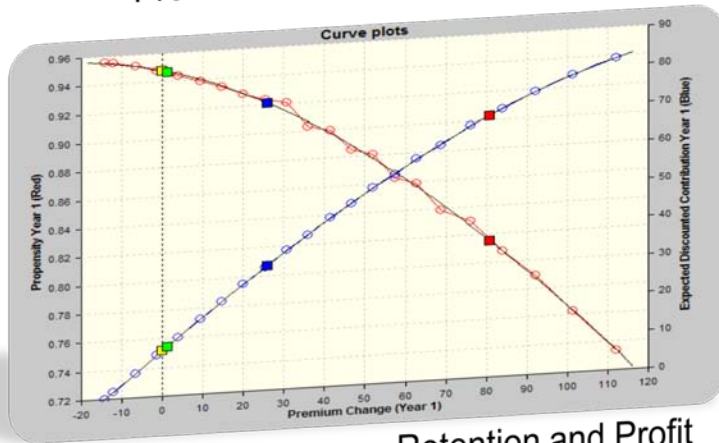
Optimization Search Space

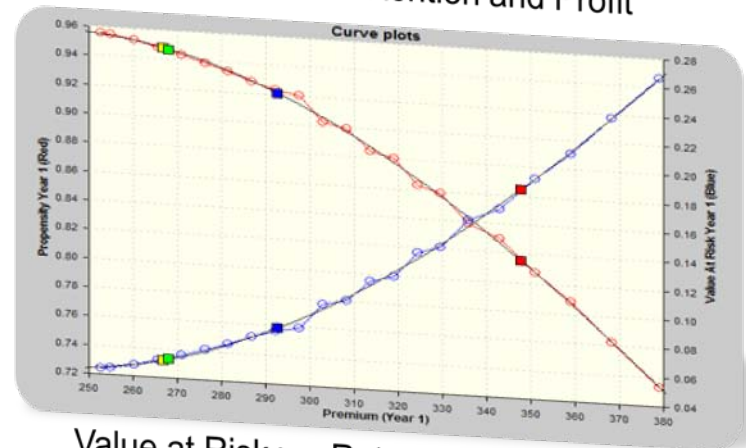Curves developed and studied for each insured

Premium vs. Retention and Profit

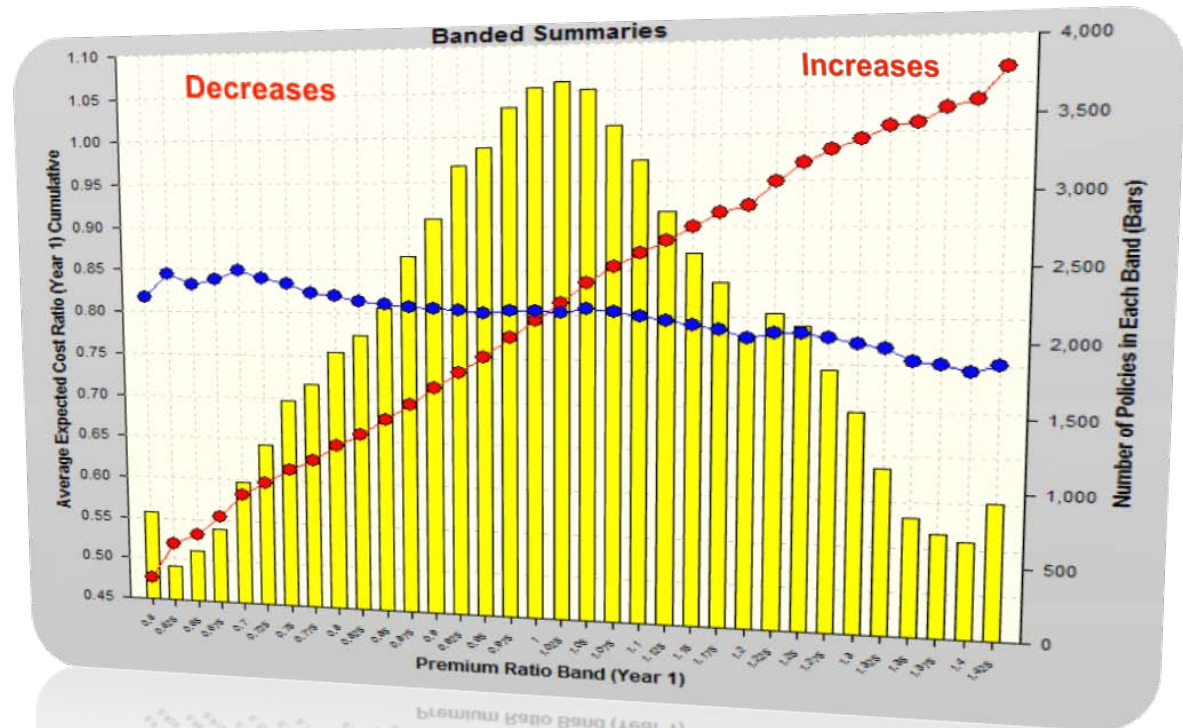Market Ratio vs. Retention and Profit

Premium Change vs. Retention and Profit

Value at Risk vs. Retention and Profit

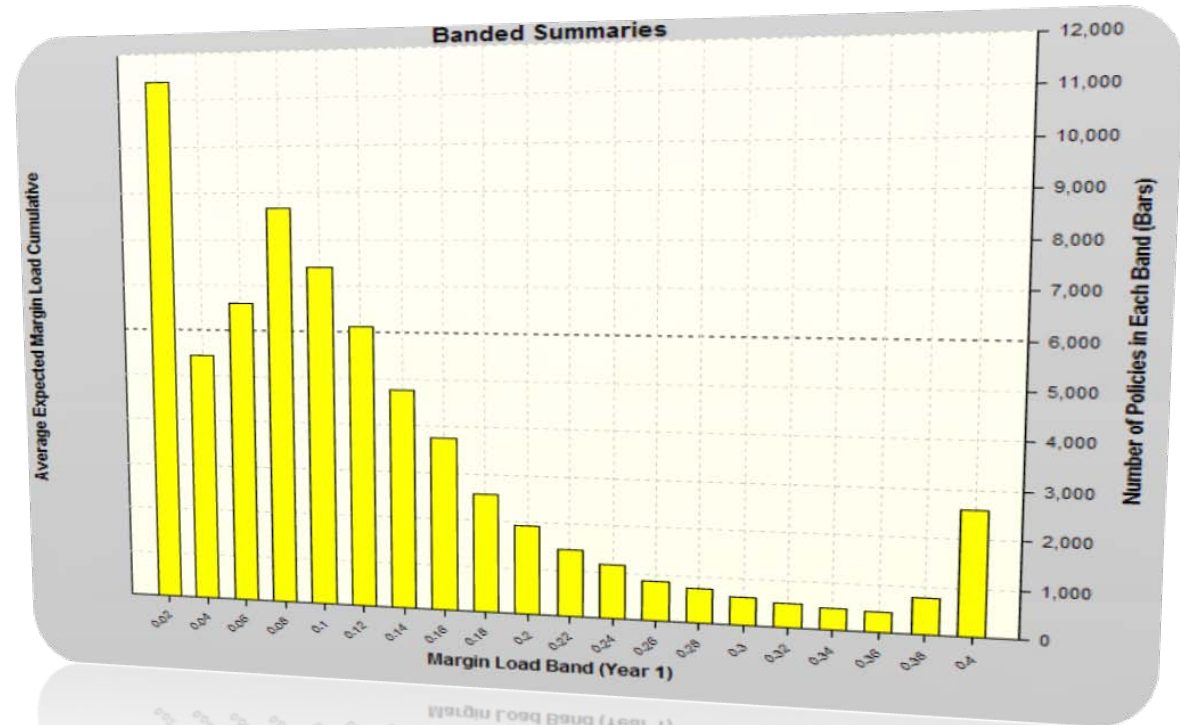# Optimization Diagnostics

- Premium change analysis

- Normal distribution of premium charges
- Optimization (blue) levels out the expected loss ratio

Optimization Diagnostics

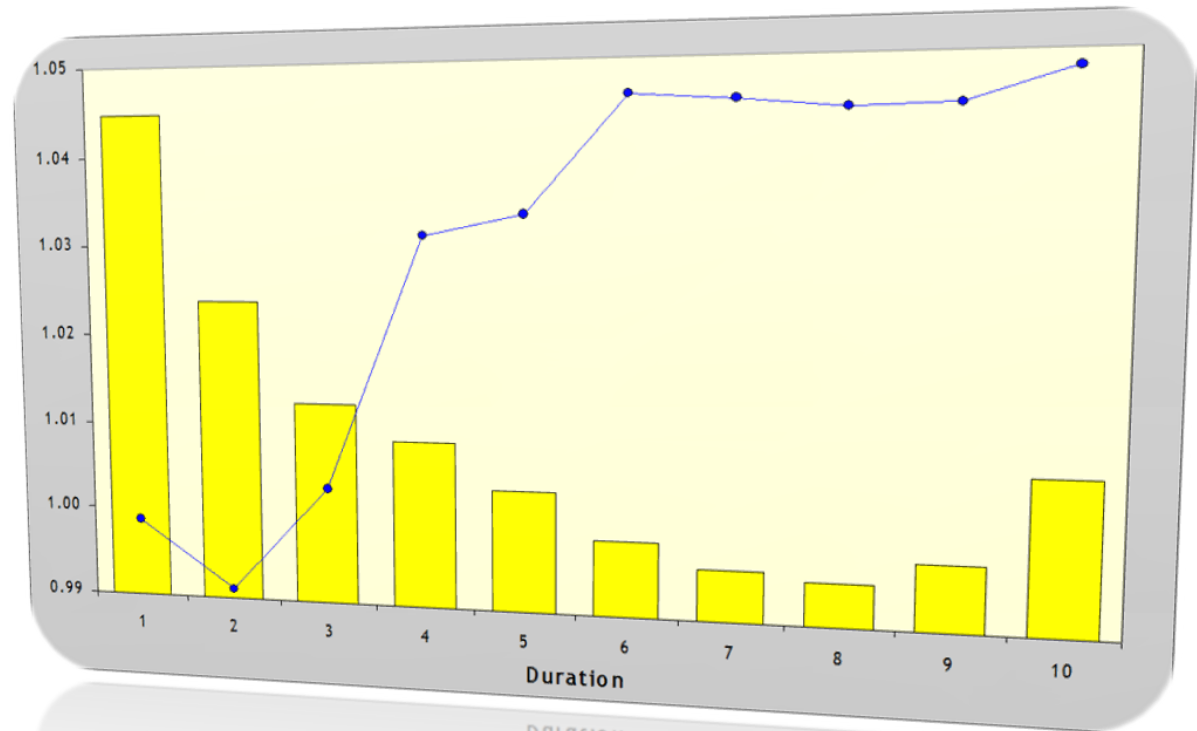- Margin loads

- Optimization has created a good spread of margins

Optimization Diagnostics

- Duration analysis

- Not overexploiting long-duration customers

Optimization Diagnostics

Expected retention by factor
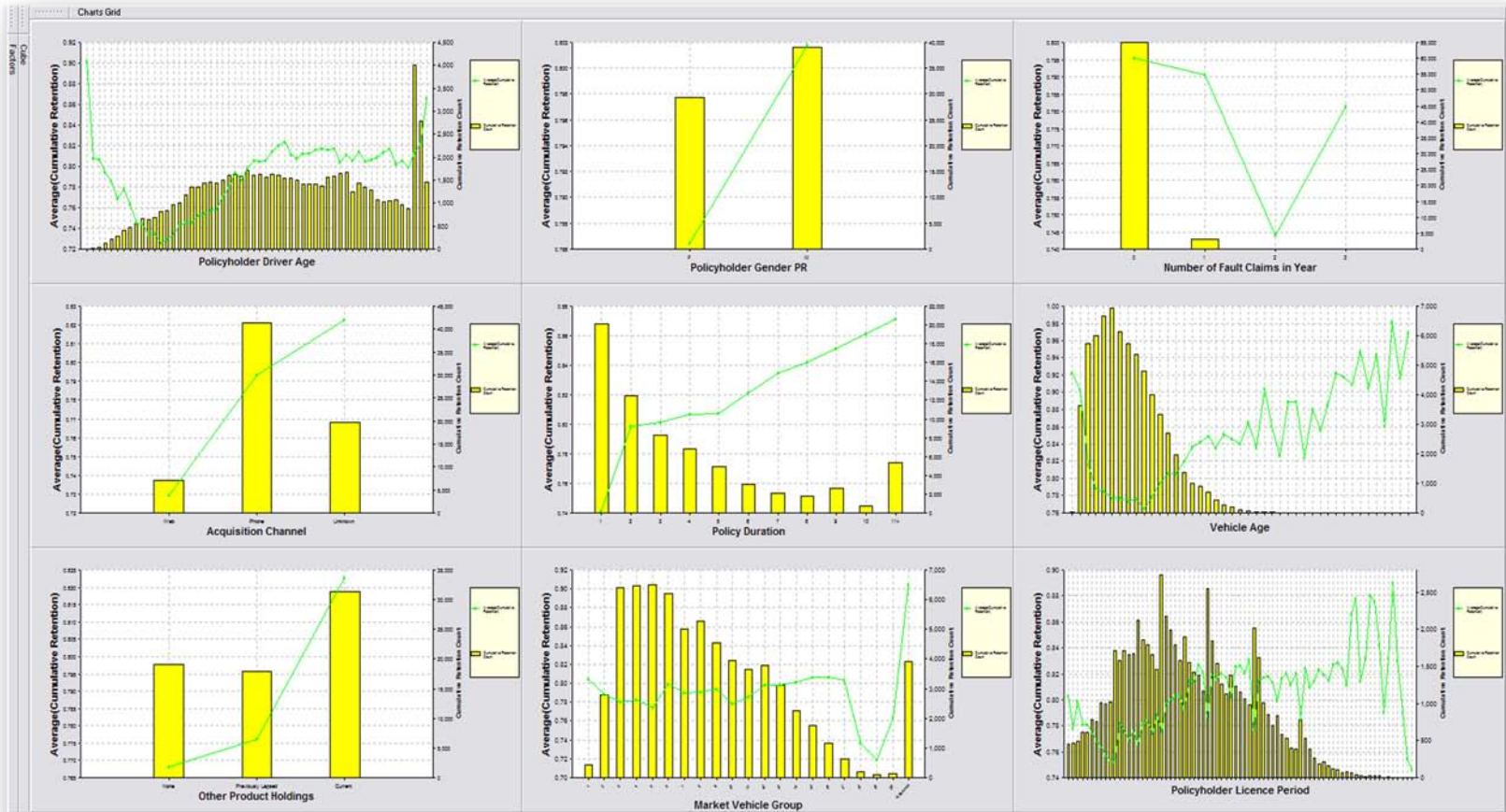
Basic Optimization Process

- Individual optimal premiums need to be transformed into a rating algorithm

Technical Models

Scenario Analysis

Optimization   Rates   Results

Optimization Process
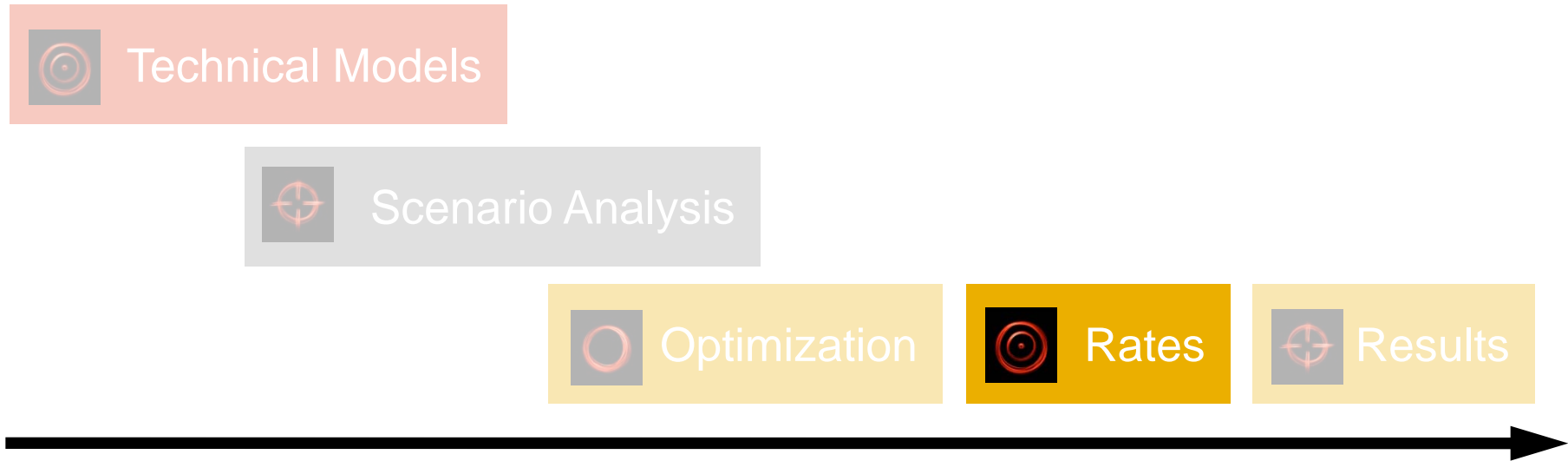
Individual Optimal Premiums
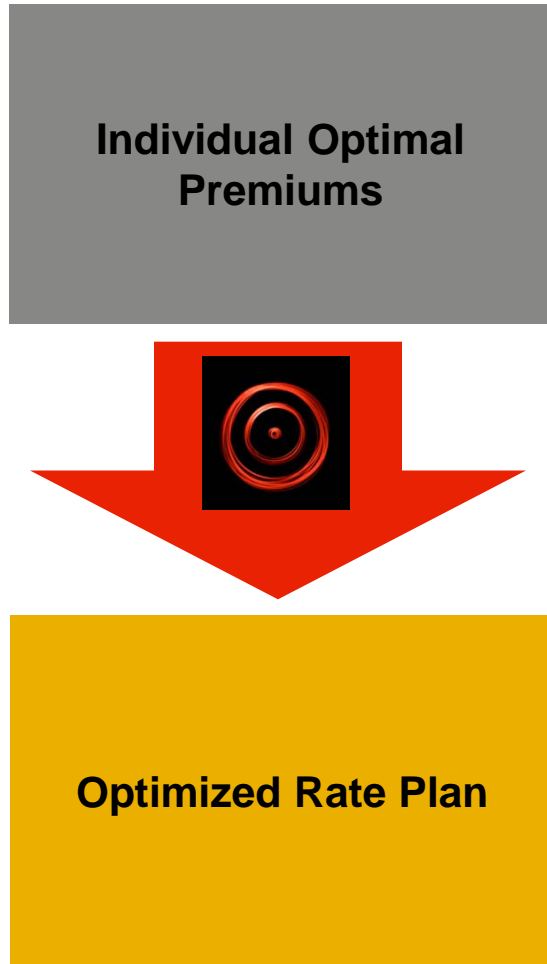
- Maximum performance lift
- Not feasible for pricing
- Useful for other decisions

Optimized Rate Plan

- Optimal within rate plan constraint
- Simple to complex
- Easier to communicate and manage

Implementation
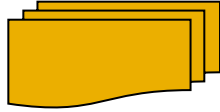
Individual optimal premiums

Policy no.	Premium
PEL009759458	327
UQJ408808153	555
KZH964999642	261
DDU700866747	349
VUQ391058119	334
YUM718736198	331
GBQ270981530	279
CSR303293030	188
XTB008693907	175
TJJ330632016	319
MFD704472553	349
ZVI955030095	277
ZJY528736252	372
VRF026498810	647
BIN297260627	555
SXT608697514	203
JAE716278042	163
XUS991829954	633
IVN822320056	641
FOD690200573	232
DCI071346826	325
SEL511154881	538

- Output of analysis so far is a list of individually optimized rates

- A table-based approach is required
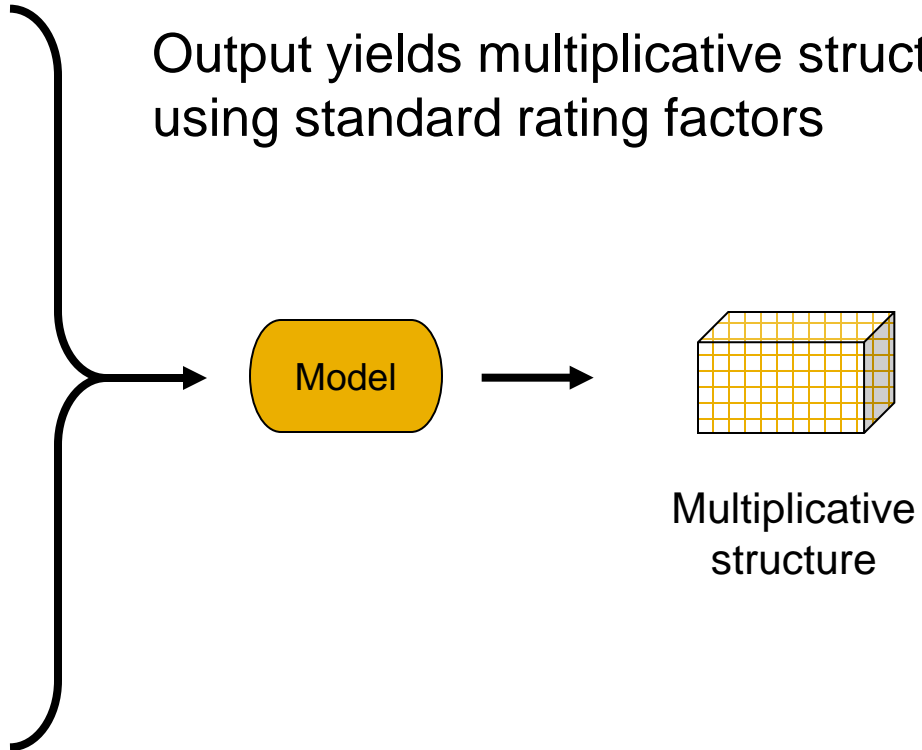
Implementation

Individual optimal premiums

Policy no.	Premium
PEL009759458	327
UQJ408808153	555
KZH964999642	261
DDU700866747	349
VUQ391058119	334
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XUS991829954	633
IVN822320056	641
FOD690200573	232
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SEL511154881	538

Output yields multiplicative structure using standard rating factors

Model

Multiplicative structure

Implementation

Individual optimal premiums

Policy no.	Premium
PEL009759458	327
UQJ408808153	555
KZH964999642	261
DDU700866747	349
VUQ391058119	334
YUM718736198	331
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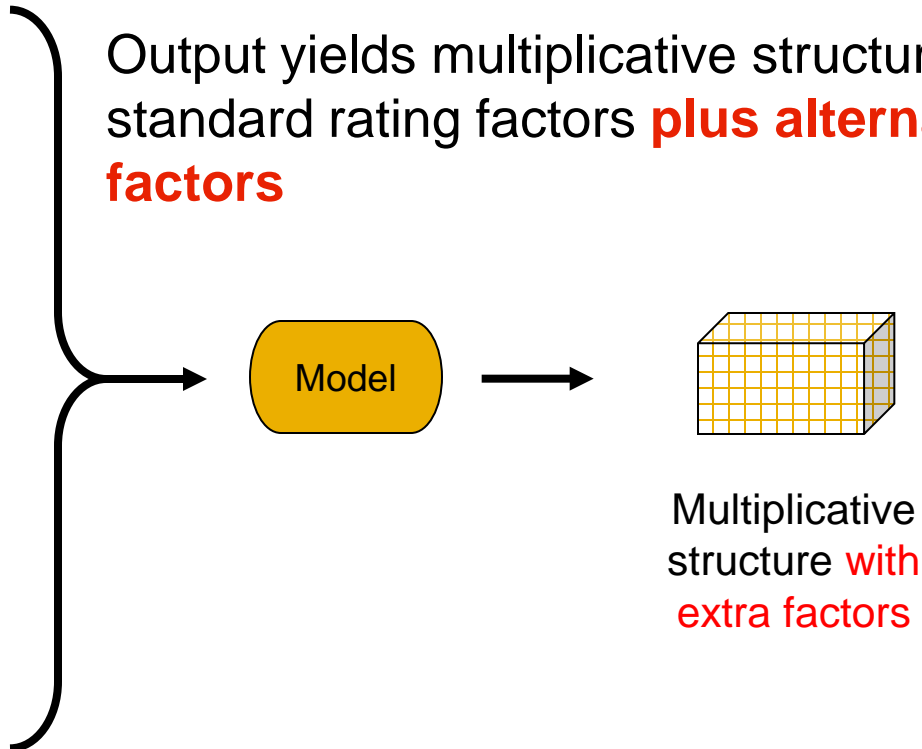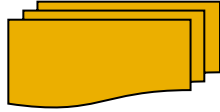Output yields multiplicative structure using standard rating factors **plus alternative factors**
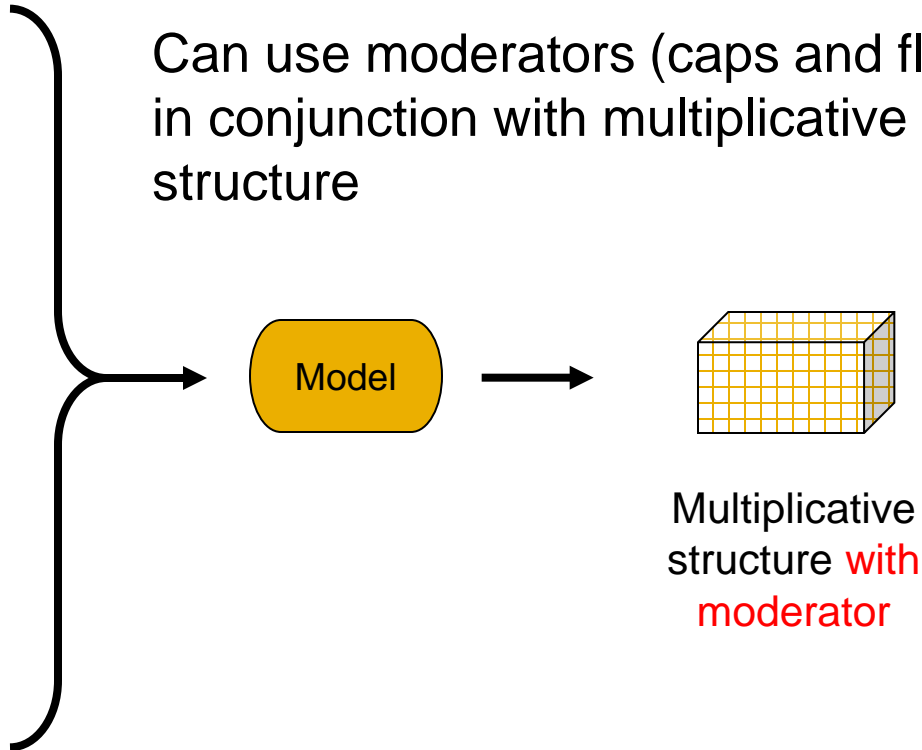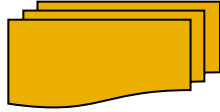
Model

Multiplicative structure with extra factors

Implementation

Individual optimal premiums

Policy no.	Premium
PEL009759458	327
UQJ408808153	555
KZH964999642	261
DDU700866747	349
VUQ391058119	334
YUM718736198	331
GBQ270981530	279
CSR303293030	188
XTB008693907	175
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XUS991829954	633
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DCI071346826	325
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Can use moderators (caps and floors) in conjunction with multiplicative structure

Model

Multiplicative structure with moderator

Implementation

Individual optimal premiums

Policy no.	Premium
PEL009759458	327
UQJ408808153	555
KZH964999642	261
DDU700866747	349
VUQ391058119	334
YUM718736198	331
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XUS991829954	633
IVN822320056	641
FOD690200573	232
DCI071346826	325
SEL511154881	538

Can create scoring algorithm similar to tiering approach

Model → Score → A B C
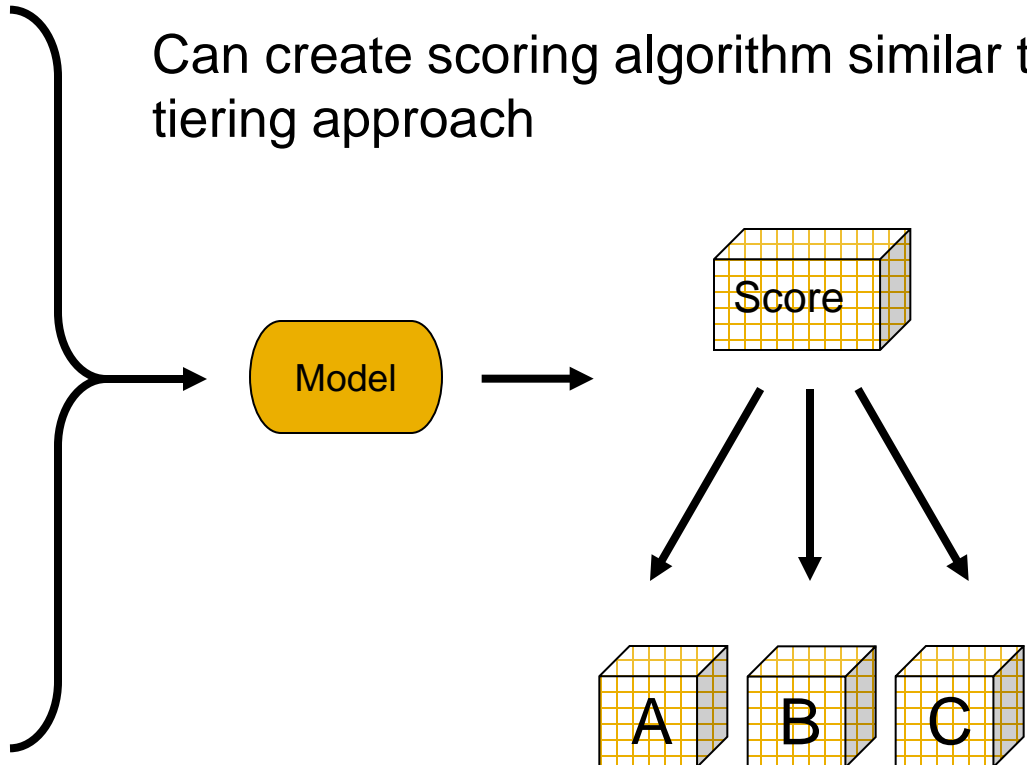
Implementation

Profit uplift comparison

Percentage Lift in Profit at Equal Volume
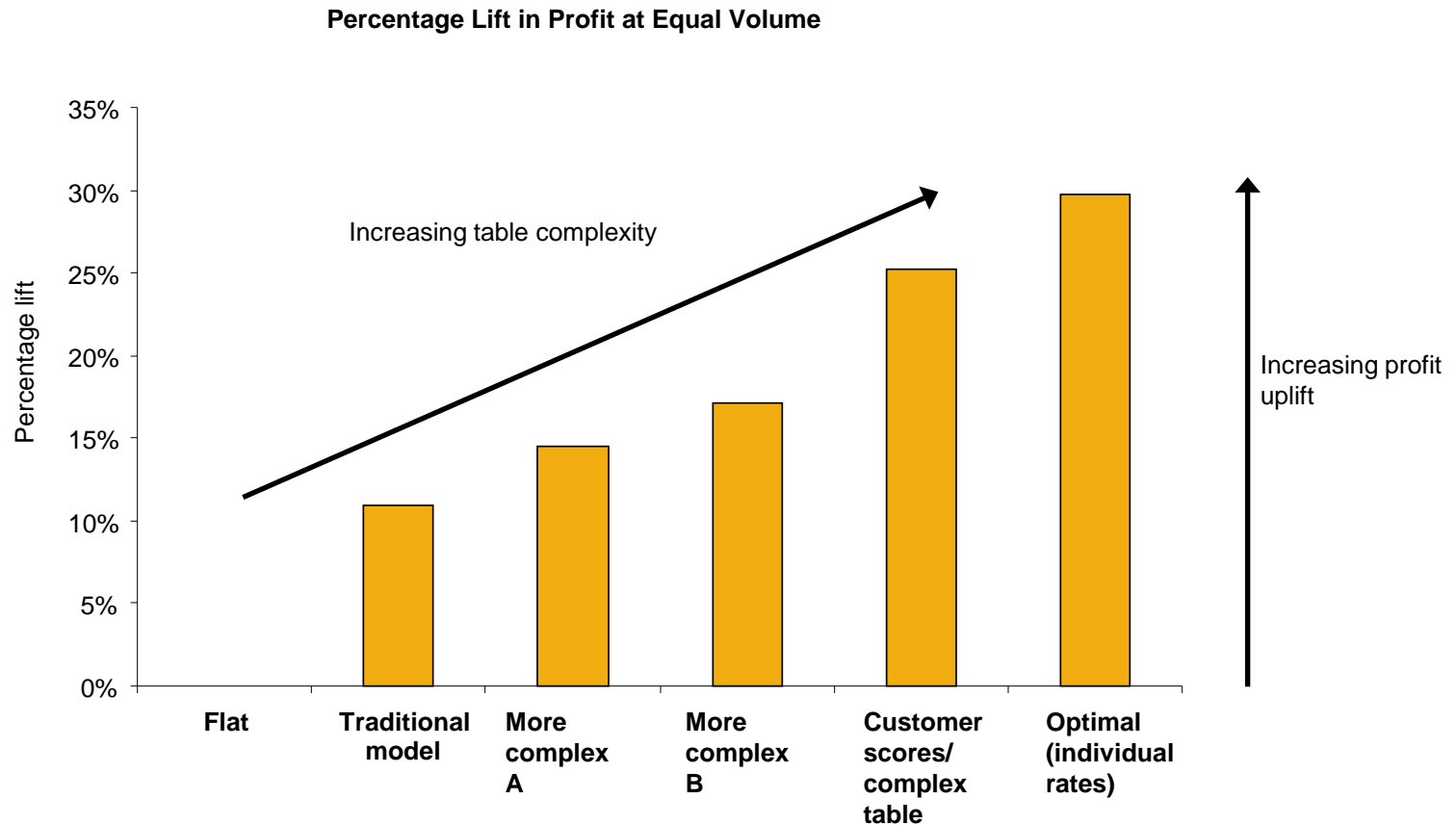
Why not optimise the ratebook directly?

- Methods exist which allow direct optimization of given rating structure

- Not an improvement of modelling individually optimized rates

- Does not show loss of potential lift of enforcing the given rating structure

- Modeling individually optimized rates indicates when new factors/scores should be considered

Price Optimization Summary

- The insurance industry has always sought to integrate loss costs and customer demand – has done so rather subjectively and with little scientific rigor

- Price optimization framework systematically integrates this information and will help you meet and exceed financial and market goals

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