From traditional pricing to pricing optimization

Czech Society of Actuaries

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Building a better working world

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Agenda

- Introduction to pricing
- Pricing uncertainty
- Behavioral economics
- Concept of pricing optimization
- Implementation of pricing optimization
- The use of pricing optimization
- Summary

Cost based pricing vs. market pricing

Nowadays, traditional pricing based on risk and cost alone is no longer sufficient. In order to make rates efficient, the broader view, blending quantitative as well as qualitative information, is necessary.

- Traditional actuarial pricing indicates the rate is too high (too low), it should be decreased (increased).

Cost based indication	
Rate too high	Decrease rate
Rate too low	Increase rate

Competitive analysis indication

Rate too low	Rate too high
Increase rate	Decrease rate

- The same is true if we look at the rate as part of competitive analysis exercise

Competitive analysis indication

Cost based indication	Rate too low	Rate too high
Rate too high	?	Decrease rate
Rate too low	Increase rate	?

- The question is what to do, if the current rate is somewhere between the cost based pricing and the competitive analysis indication?

?	Decrease rate
Increase rate	EXIT?

Behavioral economics

?	?
Increase rate	EXIT?

- Should insurer exit if rate is in the bottom right quadrant?
- Should insurer really decrease rate if rate is in the top right quadrant? According to behavioral economics: not always.

Traditional rating factors in motor insurance

There are many rating factors which could be significant for pricing. The nominal contribution of each rating factor to the final tariff varies across risk profiles. The set of statistically significant rating factors is dependent on the market characteristics and the target segment.

	MTPL	Casco
Key	► Driver's age ► Vehicle's age ► Yearly mileage ► Vehicle characteristics ► Type of usage ► Zip code ► Claim history	
		► Vehicle's value ► Deductible
Moderate	► Occupation ► Marital status ► # drivers ► Vehicle modifications	
	► Vehicle's value	► Garaged ► Alarm/immobilizer ► Other security systems
Additional	► Payment frequency	
Prohibited	► Gender	

As gender-based pricing is currently prohibited, other rating factors must be considered and pricing approach should be adjusted accordingly.

The use of telematics statistics could differentiate the rating in a similar way to gender.

Telematics

By providing a driver score at the new business quote stage, the rate will better reflect the true risk. It should lead to a lower price adjustment at renewal and increased persistency.

True risk drivers

The car
- Age of the car
- Condition of the car
- Make and model of the car

The driver
- Age of the driver
- Experience of the driver
- Impairments of the driver

Where the car is driven
- Traffic density
- Type of road
- Traffic enforcement

When the car is driven
- Day or night
- Weather conditions
- Seasonal use only

How the car is driven
- General adherence to law & regulations
- Length of journeys
- Acceleration, deceleration, and speed of car on different road types/traffic density

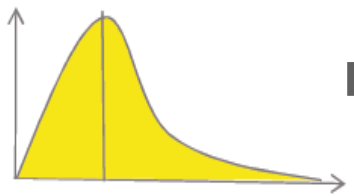
Traditional insurance

Currently, insurers use the following proxy factors in an attempt to capture the true risks:

Car factors
- Age of the car
- Vehicle value
- Vehicle group

Driver factors
- Age of the driver
- Claims history

Other factors
- Socio demographic
- Geographical



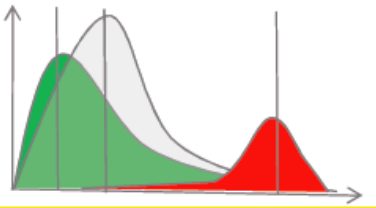
Telematics data

The majority of the true risk drivers are only available with telematics

How the car is driven
- General adherence to law & regulations
- Length of journeys
- Acceleration, deceleration, and speed of car on different road types/traffic density

Where the car is driven
- Traffic density
- Type of road
- Traffic enforcement

When the car is driven
- Day or night
- Weather conditions
- Seasonal use



Proxy factors result in traditional pricing model (yellow) being skewed by the smaller, bad driving population. **Telematics information can isolate these bad drivers** (red) and help insurers offer lower rates to the majority of the customers (green).

Saving on claims costs

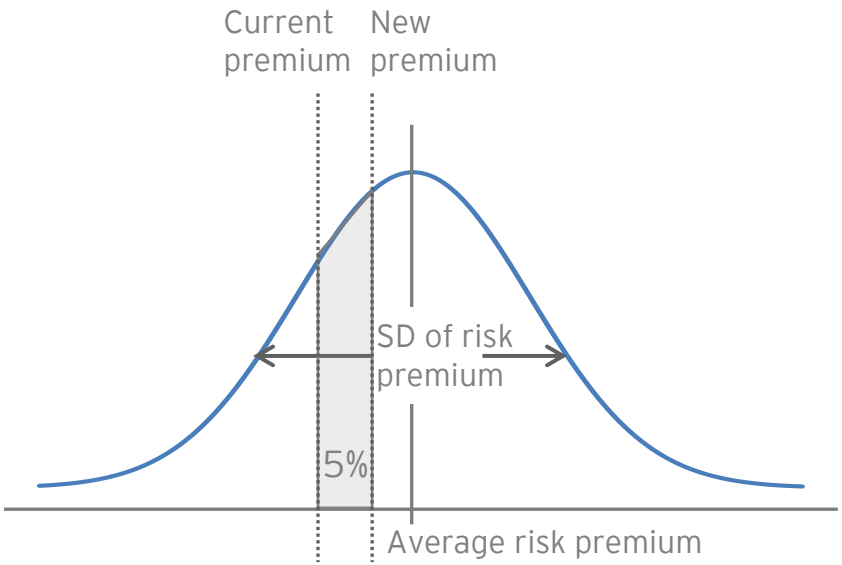
The customer incentive to improve driving behavior in order to reduce their premium could result in better claims experience.

Pricing uncertainty and adequacy

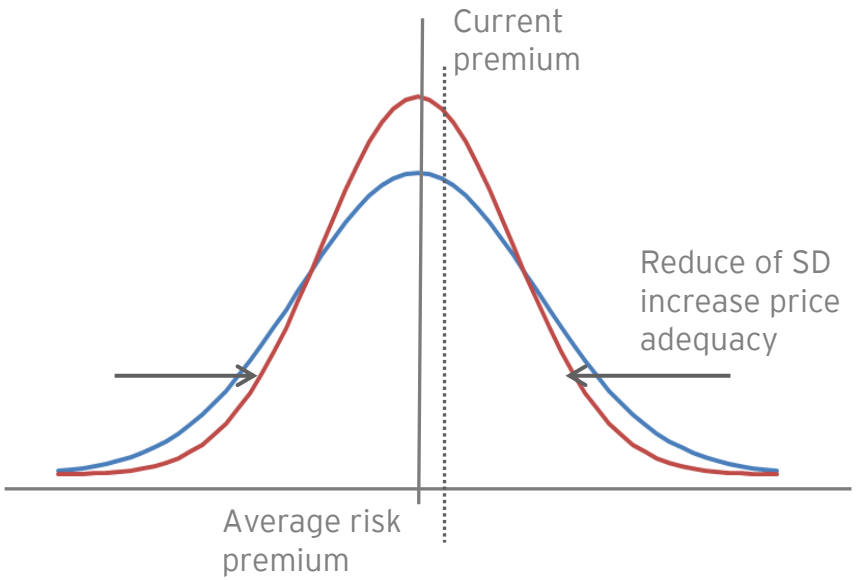
- Having the standard deviation of risk premium, we could calculate
  - Pricing uncertainty = standard deviation / average claim
  - Price adequacy = Φ[(Premium – average risk premium)/SD of risk premium]
    - Other definition of price adequacy is possible
- Possible applications are
  - Evaluate and optimise price adequacy of whole portfolio
  - Monitor and adjust price adequacy by segments
  - Use price uncertainty as a rating factor
- And generally, it has benefit of improving the certainty of underwriting results

Application 1: evaluate and optimise price adequacy of whole portfolio

- There are several options to improve the price adequacy
  - Increase price
    - SD helps to identify how much rate increase is needed to achieve targeted price adequacy



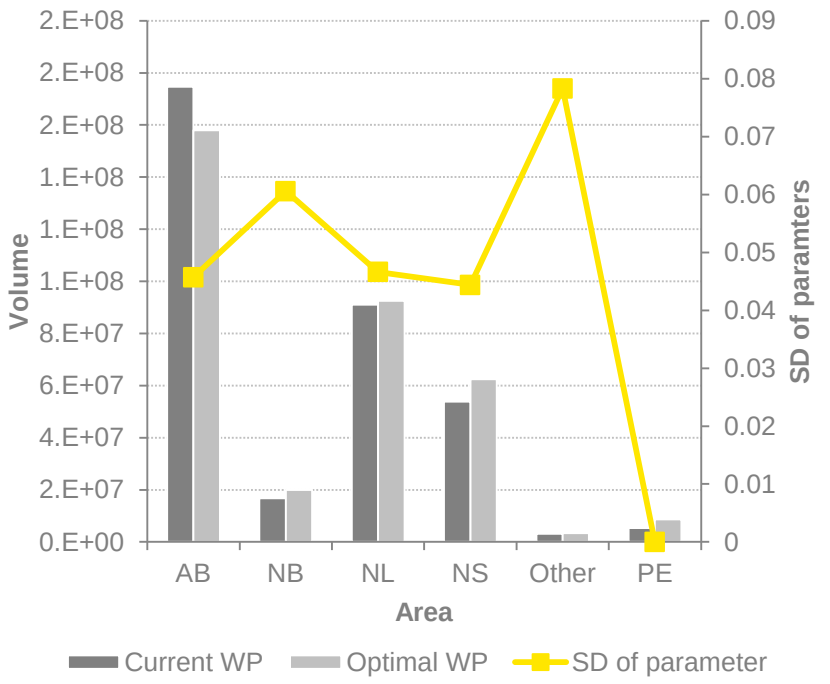
- Optimise (reduce) the standard deviation and pricing uncertainty



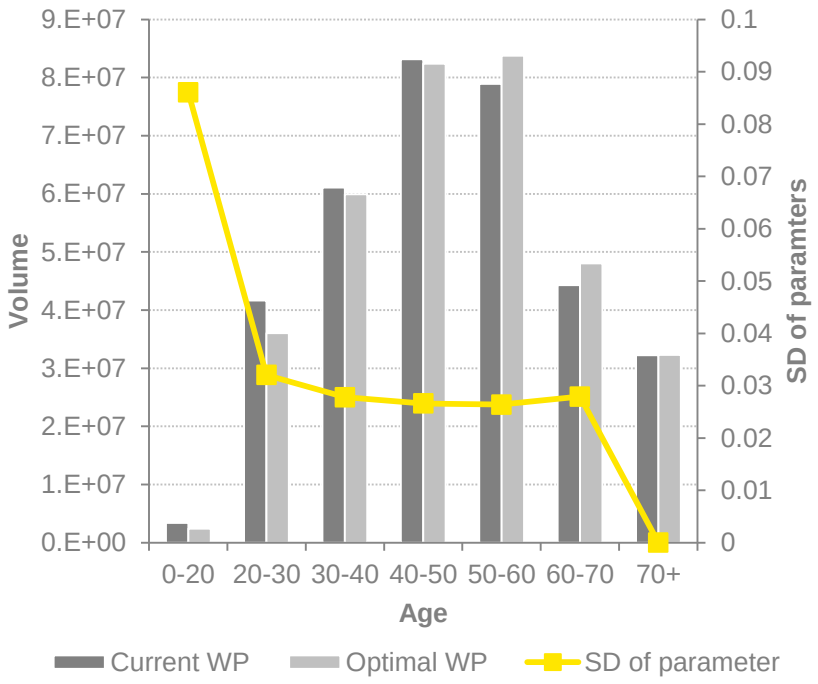
Application 1: evaluate and optimise price adequacy of whole portfolio

- Optimise (reduce or increase) the standard deviation/pricing uncertainty
  - Reduce volume in risky segment
  - But not always the case, diversification benefits are important
  - Impact on SD is c. 1% for each individual factor

Minimise standard deviation by area



Minimise standard deviation by age



- Assumptions
  - Control volume without change price

Application 2: Monitor and adjust price adequacy by segments

- Example: Area

	Pricing uncertainty	Number of policies	Risk premium	Written premium	Price adequacy
AB	1.0%	336,601	174,695,920	171,921,579	5%
NB	2.7%	50,126	16,803,081	17,591,200	96%
NL	1.3%	236,415	90,994,634	92,037,264	82%
NS	1.5%	148,388	53,840,366	54,546,086	80%
Other	6.5%	7,926	3,170,869	3,210,288	58%
PE	4.1%	16,134	5,322,567	5,520,625	82%
Total	0.7%	795,590	344,827,436	344,827,041	50%

Application 3: Use price uncertainty as a rating factor

- This depends on hypothesis that need to be tested
  - Risky policies typically have low elasticity

Price Uncertainty	No of policies	Written premium	Risk premium	LR	Elasticity	Price change	No of policies	Written premium	Risk premium	LR
1	41,245	21,301,041	21,872,373	102.7%	9	-0.2%	42,169	21,724,074.60	22,362,423.37	102.9%
2	309,863	152,306,786	152,933,351	100.4%	8	-0.5%	323,048	157,942,882.67	159,440,657.69	100.9%
3	230,791	103,975,513	103,642,776	99.7%	7	0.0%	230,045	103,687,251.87	103,307,728.27	99.6%
4	84,924	40,257,245	39,786,377	98.8%	6	0.9%	80,486	38,485,787.07	37,707,221.27	98.0%
5	37,119	13,539,671	13,275,558	98.0%	5	2.2%	33,033	12,314,572.52	11,814,268.33	95.9%
6	12,160	4,575,580	4,496,461	98.3%	4	4.8%	9,827	3,875,021.83	3,633,714.05	93.8%
7	19,396	4,714,544	4,864,911	103.2%	3	11.1%	12,948	3,496,102.97	3,247,742.89	92.9%
8	47,471	3,424,573	3,290,539	96.1%	2	16.4%	31,942	2,681,194.63	2,214,105.81	82.6%
9	12,621	732,088	665,090	90.8%	1	39.1%	7,686	620,153.28	405,025.92	65.3%
Total	795,590	344,827,041	344,827,436	100.0%			771,184	344,827,041	344,132,888	99.8%

Behavioral economics

Human behavior strongly influences insurance purchasing decisions; hence insurers should use not only qualitative and quantitative information when pricing a risk, but also behavioral information

- Rational expectations is based on the assumption that economic actors are rational, i.e. they:
  - maximize their utility,
  - have stable preferences,
  - accumulate optimal amount of information.
- However, these assumptions do not always hold.
- There are two types of reasoning:
  - Type 1: automatic, effortless, associatively coherent,
  - Type 2: controlled, effortful, logically coherent.
- Most of our mental operations are Type 1. Therefore, when estimating an unknown quantity, we tend to start with a known quantity (an "anchor") and adjust from there. For example, most policyholders buy too much insurance:
  - full-coverage MTPL policies,
  - non-deductible medical plans,
  - collision damage waiver for rental cars: ≈$15/day ≈ $5400/year.

Behavioral economics – rational expectations – example (1)

In *Predictably Irrational*, Dan Ariely describes the following case. The first version, A, was offered by the *The Economist* while the second one, B, was invented as a hypothetical situation in order to show framing effect.

How we decide – version A

The Economist magazine offers the following three options:

- **Economist.com subscription – $59**

  One-year subscription to Economist.com. Includes online access to all articles (during the year) from *The Economist*.

- **Print subscription - $125**

  One-year subscription to the print edition of *The Economist*.

- **Print & web subscription - $125**

  One-year subscription to the print edition of *The Economist* and online access to all articles (during the year) from *The Economist*.

Pick the type of subscription you want to buy or renew

Behavioral economics – rational expectations – example (2)

How we decide – version B – without print only option

The Economist magazine offers the following two options:

- **Economist.com subscription – $59**

  One-year subscription to Economist.com. Includes online access to all articles (during the year) from *The Economist*.

- **Print & web subscription - $125**

  One-year subscription to the print edition of *The Economist* and online access to all articles (during the year) from *The Economist*.

Pick the type of subscription you want to buy or renew.

Results

Ariely tested the behavior of two alike groups of students

- **Version A:**
  - Internet-only access 16 students
  - Print edition 0 students
  - Internet plus print edition 84 students
- **Version B:**
  - Internet-only access 68 students
  - Internet plus print edition 32 students

- Option 2 (print edition only) was little more than a decoy and nobody was expected to buy it
- It only served as a basis for comparison against which Option 3 looked good
- Does maximizing utility over a stable set of preferences really describe how we decide?

Why we change the insurance company

- Anchoring effect - renewal customers use their current pricing rather than competitor prices as an anchor point
- Confirmation bias - the difference between the offered and current premium influences renewal decisions
- Availability bias – policyholders favor easily available and familiar information
- The difference between the offered and current premium that triggers a shopping event varies between individuals
- It is important to analyze that switching point in order to predict customers' behavior

Behavioral economics – implications for pricing optimization

Detailed information about customers is crucial in developing pricing strategy

- As shown in previous examples, human behavior and preconceptions can influence their decision whether to buy an insurance and how much to pay for it
- Customer characteristics are reflected in the price elasticity of demand, which is the basis for pricing optimization
- This means that history and background of the insured person can affect their willingness to pay higher premium
- Premium increases upset insurance customers more than reductions please them. Customers whose rates fluctuate – up and down – are likely to be less happy than those with steady premiums. Companies should take this into account when making renewal decisions
- Companies should strive to track all interactions with their customers so that they can gather information about their behavior and reactions and then incorporate it into pricing strategy

How to optimize pricing decisions and maximize customer value

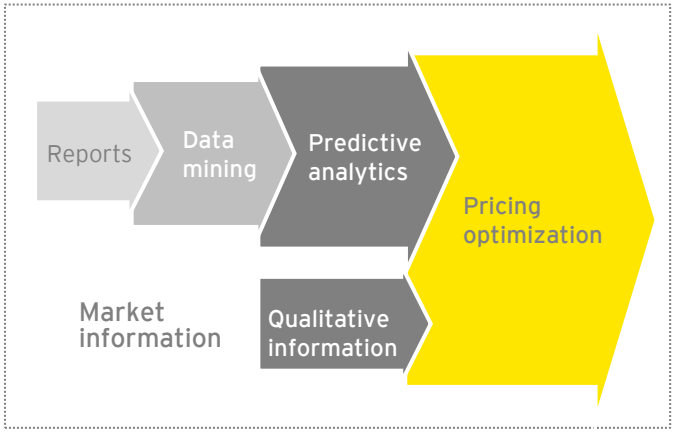
- Analyze not only qualitative and quantitative information but also behavioral information, because each customer reacts differently to change in price
- Analyze customer's price elasticity in order to offer them the right price that maximizes customer lifetime value
- By targeting the optimal customer mix, it is possible to match the growth and profit objectives (e.g. it is possible to implement such strategy that maximizes profit given that retention rate is kept constant)

Why pricing optimization matters to insurance companies

Pricing optimization is already revolutionizing the insurance market, bringing significant benefits to the industry

Background

In recent years, the insurance industry realized it can no longer rely on standard business analytics to define pricing strategy. Simply relying on reports and data mining to produce predictive analytics has become outdated. Pricing is a combination of art and science, and it should be a decision making process that blends quantitative as well as qualitative information.

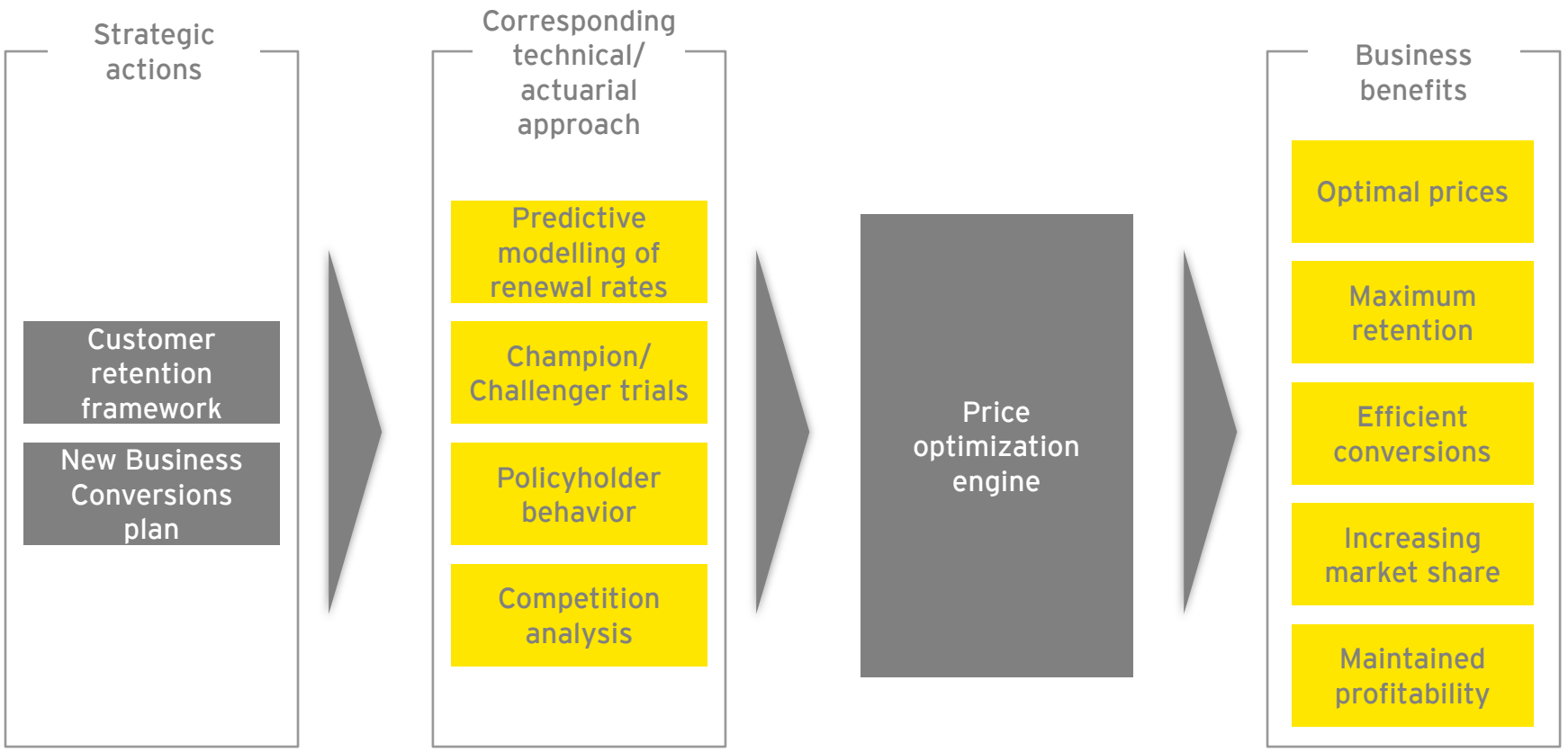


What is price optimization?

The goal of the price optimization process is to find the premium level to achieve specific goals set by insurer, such as maximizing overall margin. Different businesses may have different objectives e.g. a start-up company may seek to maximize sales, while a mature company strives to maximize profitability.

In price optimization, insurers quantify the relationship between volume of sales and profit. Information, such as customer behavior, corporate constraints, risk, operational costs, and margins are incorporated into the model before mathematical optimization techniques are used to simulate outcomes and produce the best pricing strategy.

Price optimization framework



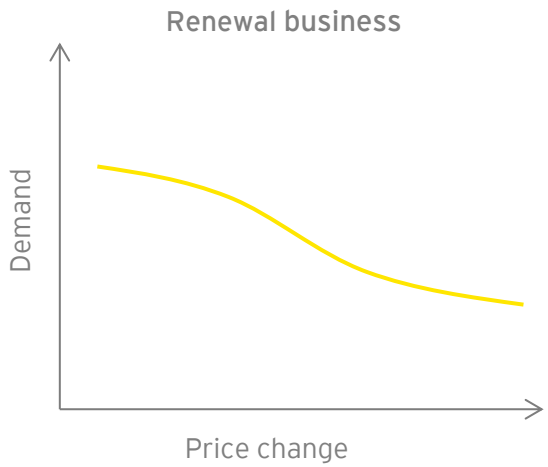
Pricing process

Actuarial pricing | Pricing optimization

Process	Data preparation	Building GLM models	Loadings and derivation of commercial tariff	Price elasticity / competitive analysis	Derivation of final commercial tariff
Considerations	**Internal data** ► Extract of policy and claims databases split by products and risks ► Typically 2-3 years of the most recent history ► Data cleaning: very important and usually necessary exercise ► Merging policy and claims databases by policy ID **External data** ► Tariff structure of competitors ► Quotations of competitors for selected model points	► Data analysis: policy and claims database statistics, one-ways as introductory step to GLMs ► GLM models per product and per risk (e.g. separately for damage and theft in Casco) ► Poisson GLM models for claims frequency ► Other GLM models for severity (e.g. Gamma, power distribution) ► Merging frequency and severity models into burning cost models => actuarial tariff	► Estimation of loadings for reserves: annuities and IBNR, especially BI claims ► Estimation of loadings for acquisition expenses, administration expenses, claim handling expenses, recoveries and recourses ► Decision regarding expected profit margin	► Data gathering and analysis: renewals, competition prices, price elasticity data (questionnaires, price tests based on existing portfolio, conversion rates) ► Model development ► P&L projections under various scenarios ► Decision on tariff adjustments (pilot to be considered)	► Qualitative and strategic considerations ► IT capabilities and price change cycles ► Distribution channels

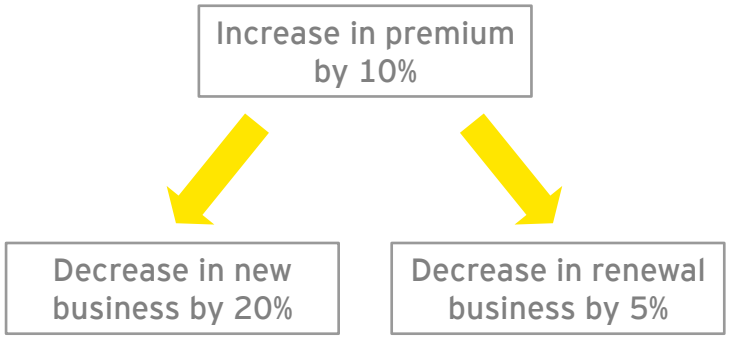
Price elasticity

Price elasticity for new and renewal business:



Interpretation:

- Elasticity differs significantly between new and renewal business
- New business is highly elastic to changes in price
- Renewal business has relatively low elasticity



Price elasticity

Definition:

$$E_d = \frac{P}{Q} \cdot \frac{\partial Q}{\partial P}$$

where:

Q – quantity demanded
P - price

Interpretation:

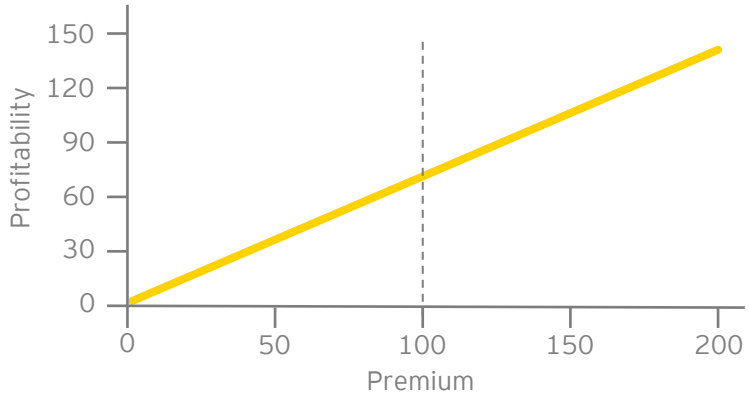
- Price elasticity reflects the percentage change in quantity demanded due to a small percentage change in price

Implication:

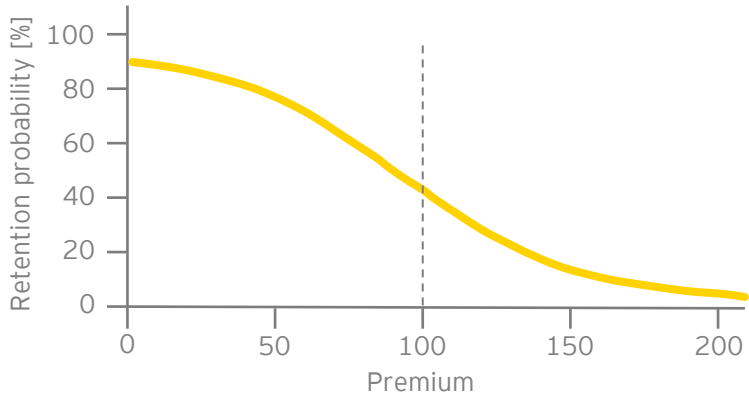
- $E_d = 0$ – perfectly inelastic demand (no change in demand due to change in price)
- $0 < |E_d| < 1$ – inelastic demand (percentage change in demand is lower than the percentage change in price)
- $|E_d| = 1$ – unitarily elastic demand (change in demand proportional to change in price)
- $1 < |E_d| < \infty$ – elastic demand (change in demand more than proportional to change in price)

Expected profit

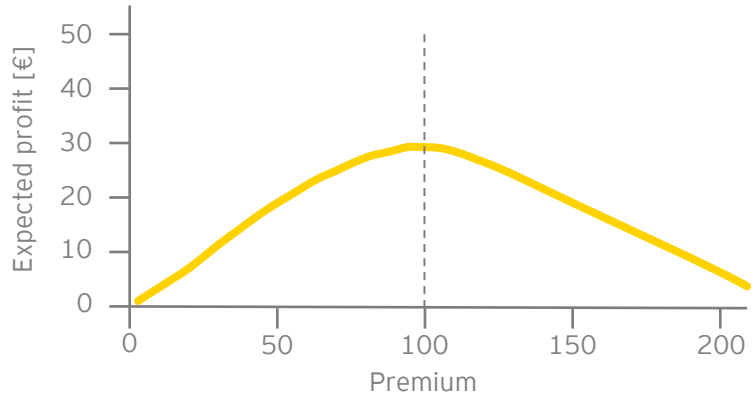
Profitability vs. premium



Retention probability vs. premium



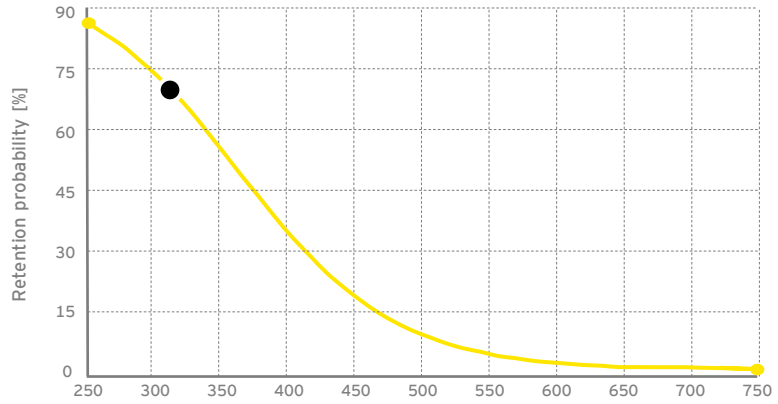
Expected profit vs. premium



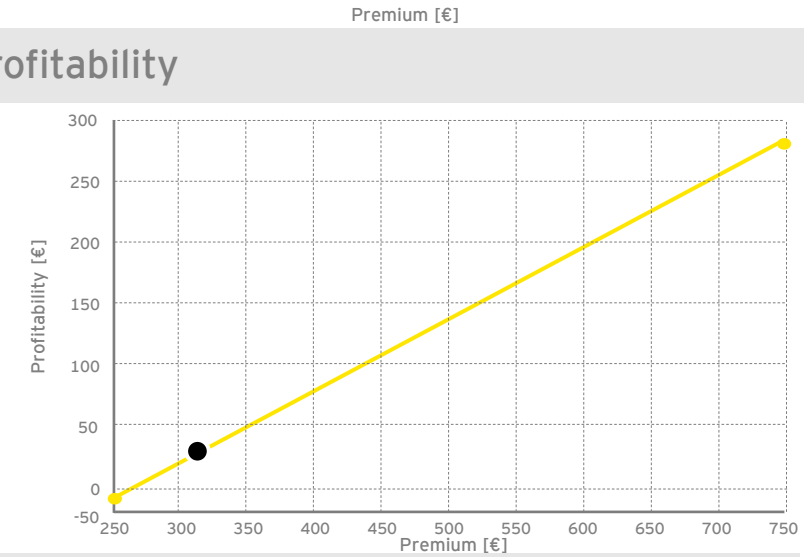
- Increasing the premium increases the profitability.
- However, increasing the premium decreases the probability of retaining the client.
- The purpose is to find the premium to optimize profit and volume based on a number of business constraints.

Pricing optimization – example (1)

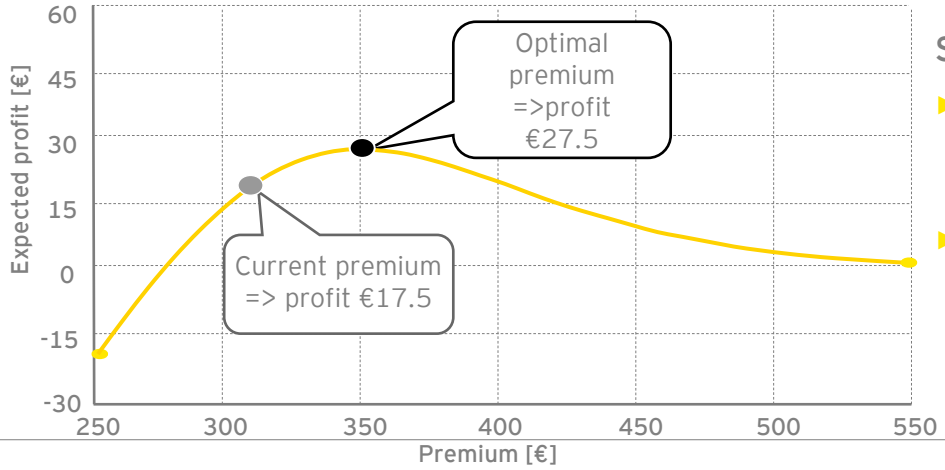
Price elasticity



Profitability



Expected profit curve

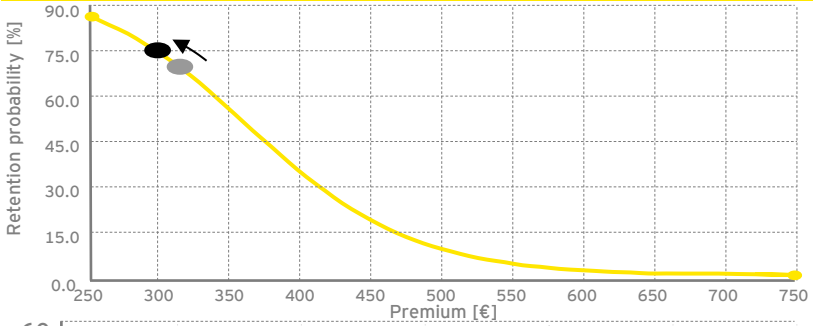


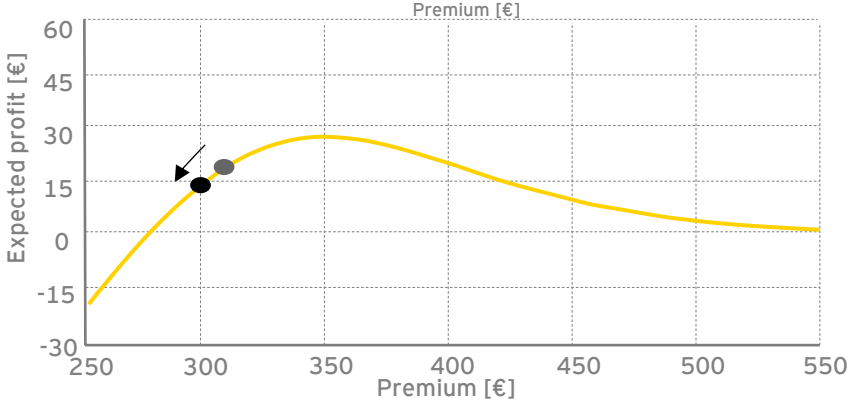
Single policyholder perspective

- The current premium of €315 is **not optimal** – yielding a profit of **€25** or expected profit of €17.5 (probability of renewal of 70%).
- We can improve expected profit to €27.5 by increasing the premium to €350 (profit of €50 given lower probability of renewal of 55%).

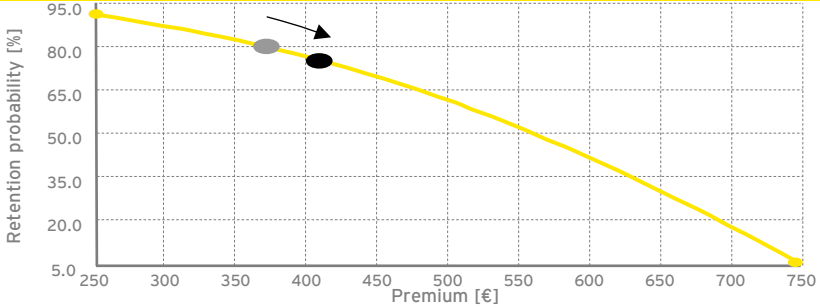
Pricing optimization – example (2)

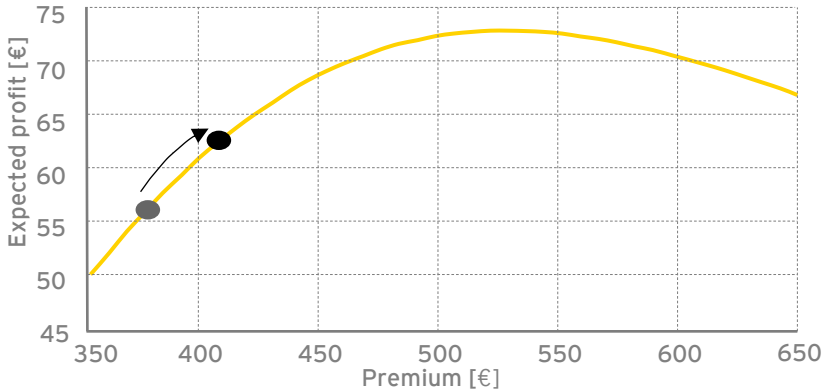
Portfolio view





Decreasing premium of Customer A from €315 to €300 **decreases expected profit** from €17.5 to **€15**.





Increasing premium of Customer B from €375 to €415 **increases expected profit** from €57 to **€62.5.**

We are increasing our expected profit by a total of **€3**.

€62.5 - €57.0 = €5.5

€15.0 - €17.5 = - €2.5

Total Profit of €3.0

Predictive modelling of renewal price elasticity

Renewal database preparation

Recent 3 – 5 years

Merge policies to identify renewals

Policy database

Attach renewal risk factors

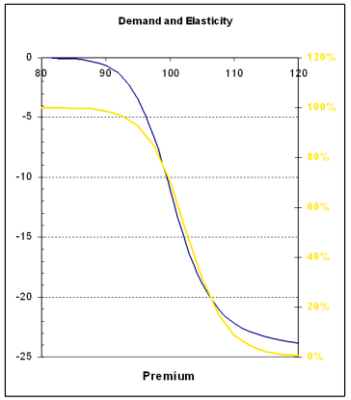
Clean the data for modelling

GLM models of price elasticity for renewals

$$\widehat{Renewal\_rate} = int + \frac{Prem\_new}{Prem\_old} + \frac{Prem\_market}{Prem\_old} + age + region$$

Elements affecting renewal rate:

- Policyholder characteristics: age, income, region,
- Policy type (only MTPL or package),
- Satisfaction – non-measurable...,
- Company service quality,
- Distribution channel.



Applications

- Feed existing commercial pricing models
- Use to predict renewals - GWP and technical result
- Can be used in each tariff modification (multiple times a year)
- In the future may feed the model in the price optimization project

Champion / challenger trials

Champion / challenger trials

	Price Adjustment		
	New Business	1st Renewal	Subsequent renewals
Champion Rate	0%	0%	0%
Challenger Rate 1	5%	3%	15%
Challenger Rate 2	-5%	-2%	-10%

Results

- New business elasticity based on the change in Conversion between the Champion rates and Challenger rates.
- Renewals business elasticity based on the change in Conversion between the Champion rates and Challenger rates.
- Two elasticity measures - elasticity of price increases and price decreases.
- Elasticity measures at channel level / cover level

Best in class

- Full regression model providing a point estimate of elasticity for each policy / quote.

Key challenges

Different stages of technological development of insurance companies require different solutions for pricing optimization

	Small mutual organization	Traditional local insurance company	Insurance company - part of the international group	Insurance company focused on personal lines only	Direct insurer (e.g. operating in the UK market)
Example of insurer					
	Least advanced → Most advanced				
Characteristics	▸ Sales in one region ▸ Focused on selected profession or community ▸ Basic technology and IT systems ▸ Limited quantitative information about customers	▸ Offers both life and non-life insurance ▸ No target groups ▸ Usually several IT systems working in parallel ▸ Some information about customers necessary for pricing	▸ Characteristics similar to traditional insurance company ▸ Usually newer technology ▸ More advanced IT systems ▸ More detailed information about customers	▸ Focused on personal lines only ▸ Advanced IT systems ▸ Sometimes fraud detection systems ▸ Usually knows almost everything about customers	▸ Newest technology ▸ Advanced IT systems ▸ Often fraud detection systems ▸ Knows almost everything about customers ▸ Prices easiest to compare between insurers
Key challenges	▸ Gathering data ▸ Implementation of IT systems	▸ Assessment of data availability ▸ Standardization of IT systems	▸ Gathering additional data ▸ Implementation of pricing optimization ▸ Integration with other systems	▸ Assess quality of input data currently used in PO and improve it ▸ Integration of current pricing optimization solutions with new ones	▸ Implement other modules of pricing optimization software ▸ Integrate all systems

Reality check

It is usually true that

- The modeling process, and therefore its implementation, relies on the quality and quantity of input data.
- The theory behind the calculations involved in price optimization may appear complicated.
- It can be difficult to gain buy-in from various parts of the business with a conflict between those open to the new process and those in favor of the old.
- Implementation of pricing optimization will be easier at a direct insurer than at a small mutual organization due to better quality and availability of data.

It is typically not true that

- Pricing optimization is difficult to implement.
- The process of implementing pricing optimization can take several years.
- The cost of implementation outweighs the potential benefits.
- Pricing optimization requires the replacement of entire IT infrastructure.
- There are legal constraints making implementation impossible.

The use of optimization in other industries

- Optimization can be applied not only to price, but also to other drivers of profitability
- Different software packages may be fit-for-purposed depending on industry

Manufacturing	Transportation & Logistics	Utilities, Energy and Natural Resources	Telecom	Other
▸ Inventory optimization	▸ Depot/ warehouse location	▸ Supply portfolio planning	▸ Network capacity planning	▸ Workforce scheduling
▸ Supply chain network design	▸ Fleet assignment	▸ Power generation scheduling	▸ Routing	▸ Advertising scheduling
▸ Production planning	▸ Network design	▸ Distribution planning	▸ Adaptive network configuration	▸ Marketing campaign optimization
▸ Detailed scheduling	▸ Vehicle & container loading	▸ Water reservoir management	▸ Antenna and concentrator location	▸ Revenue/ Yield management
▸ Shipment planning	▸ Vehicle routing & delivery scheduling	▸ Mine operations	▸ Equipment and service configuration	▸ Appointment & field service scheduling
▸ Truck loading	▸ Yard, crew, driver & maintenance scheduling	▸ Timber harvesting		▸ Combinatorial auctions for procurement
▸ Maintenance scheduling	▸ Inventory optimization			

Airlines

Airlines

Airlines use price differentiation regularly, as they sell tickets simultaneously to different market segments. Optimal pricing decisions can be done by:

- analysis of demand that allows for accurate customer segmentation,
- modeling of customer reaction to fares and flight attributes (duration, quality of service, fidelity programs, week-end restrictions, etc.),
- setting prices and capacity allocations at fare basis code level,
- understanding of the schedules and networks of competitors.

Example:

Schedule-sensitive business passengers who are willing to pay £300 for a seat from Warsaw to London cannot purchase a £150 ticket because the £150 booking class contains a requirement for a Saturday night stay, or a 15-day advance purchase, or another fare rule that discourages, minimizes, or effectively prevents a sale to business passengers.

- "The seat" is not always the same product. Business passenger is willing to pay more (it's not their money anyway...) in return for a seat on a high-demand morning flight, fully refundable, direct flight, and including upgrade option, space permitting, for a nominal fee.
- Airlines may also apply different pricing of "the same" seat over time, e.g. by discounting the price for an early or late booking (without changing any other fare rules).

Insurance companies

Country	How many insurers use it	How successfully insurers use it
United Kingdom	Most insurers	Quite successfully
Nordics	A couple per country (ca. 30% of the market)	Very successfully
Poland	A few (ca. 15% of the market)	Those who use it appear more successful than peers
Russia	A few (1% of the market)	No info
Belgium	Some	Appears not very successfully
Italy	At least one	No info
Netherlands	Some have started implementation	No info
Germany	Not many	No info

Summary

Market

- Rating becomes more competitive with increasing data availability and computer power
- Availability of the information to the consumers increases rapidly
- New market entrants typically price below the market
- New types of claims hurt profitability
- Regulatory constraints
- Technology helps save costs of insurers

Company specific

- Management priorities
- Availability of data
- IT projects pipeline

Thank you

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