Special Considerations and Innovation in Loss Ratio Estimation

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Agenda

1. **Special Considerations**: Loss Ratio Method
2. **Innovation:** Rate-Agnostic Bayesian Approach

Part 1

Special Considerations:
The Loss Ratio Method

The Loss Ratio Method – Background

State XX
Wicked Good Insurance Company
Private Passenger Auto: Property Damage Liability
Indicated Rate Change - Loss Ratio Method

Calendar Accident Year	(1) Earned Premium	(2) Current Rate Level Factor	(3) Premium Trend Factor	(4) Projected Earned Premium at Current Rate Level	(5) Reported Losses and Paid ALAE	(6) Loss Development Factor	(7) Loss Trend Factor	(8) ULAE Factor	(9) Projected Ultimate Losses and LAE	(10) Projected Loss and LAE Ratio
2011	$ 1,122,372	1.2161	1.1342	$ 1,548,088	$ 856,495	1.0000	0.9912	1.143	$ 970,359	62.7%
2012	$ 1,154,508	1.2176	1.1116	$ 1,562,608	$ 867,184	0.9799	0.9962	1.143	$ 967,578	61.9%
2013	$ 1,280,545	1.1311	1.0879	$ 1,575,741	$ 835,120	1.0003	1.0012	1.143	$ 955,974	60.7%
2014	$ 1,369,976	1.0892	1.0663	$ 1,591,109	$ 821,509	1.0282	1.0062	1.143	$ 971,450	61.1%
2015	$ 1,397,750	1.0991	1.0452	$ 1,605,706	$ 797,866	1.0966	1.0113	1.143	$ 1,011,357	63.0%
Total	$ 6,325,151			$ 7,883,252	$ 4,178,174				$ 4,876,718	61.9%

(11)	Selected Projected Loss and LAE Ratio	61.9%
(12)	Fixed Expense Provision	11.3%
(13)	Variable Expense Provision	17.0%
(14)	UW Profit Provision	5.0%
(15)	Variable Permissible Loss Ratio	78.0%
(16)	Indicated Rate Change	-6.2%
(17)	Credibility	100.0%
(18)	Trended Present Rates Indication	6.2%
(19)	Credibility-Weighted Indicated Rate Change	-6.2%
(20)	Selected Rate Change	-6.2%

Source: Werner and Modlin, Appendix A

What Good is a “Selected Rate Change”?

- Directly informs pricing decisions for individual accounts
- Directly informs staff goals and plans in the context of a budget
- Directly contributes to management understanding of the of the business, which influences priorities, investment decisions, etc.
- Influences booked loss ratios in financial filings
- Indirectly contributes to investor understanding of the business
- Note that the analysis embeds a proposition: “**If** we implement this rate change, **then** we will achieve this loss ratio.”

Basic Assumptions

- Past experience informs future performance
- Underlying data is complete and error-free
- Other analyses that feed into this one were done well
  - Examples: rate monitoring, trend estimation, profit margin
- Loss ratio method was implemented correctly
- Any others?

Implicit Assumption No. 1

The Loss Ratio Method Works

- **Poll:** Is this a good assumption?
- **Argument in favor:** Come on, what is this, of course it works
- **Arguments against:**
  - The most frequently used method in practice, but in practice, actuarial forecasts are often wrong (see: Schedule P)
  - Often fails backtest (exercise left to reader)
  - Efficacy not established by application of scientific method

Regarding the Scientific Method

Loss Ratio Method	. . . Bloodletting?
Critical and ubiquitous technique for actuaries	Critical and ubiquitous technique for doctors
Long history of use (decades)	Long history of use (millennia)
Consensus as to efficacy	Consensus as to efficacy
Covered at length in many scholarly texts	Covered at length in many scholarly texts
Application of scientific method TBD	Shown to be ineffective through application of scientific method by Pierre Louis in 1828

Implicit Assumption No. 2

Business Plans are Reasonable

- Why might a business plan be unreasonable?
  - Excessive growth ➔ reduced standards ➔ higher loss ratio
  - Excessive rate ➔ selection pressure ➔ higher loss ratio
- Market conditions matter!
  - When market conditions are poor, results will deteriorate
  - But plans don’t typically anticipate deterioration
  - This leads to systematic overoptimism in soft markets

Poll: Should actuaries adjust for this in their analyses?

Commercial Auto Calendar-Year Outcomes: $100m+ Portfolios,1988-2017 (n=1,382)

Percentile	Premium Improvement	LDCC Ratio Improvement	Combined Improvement
10th	-10.4%	-16.9%	-20.6%
20th	-5.6%	-10.4%	-11.2%
30th	-2.0%	-6.7%	-5.4%
40th	0.9%	-3.8%	-1.1%
50th	3.8%	-0.7%	2.8%
60th	6.6%	2.3%	6.8%
70th	9.4%	6.1%	11.8%
80th	14.2%	10.4%	19.9%
90th	24.9%	16.2%	36.4%

Implicit Assumption No. 3

Management Will Execute

Some portfolios are managed better than others.

Poll: Should actuaries adjust for this in their analyses?

Same Market, Different Companies

		Company A			Company B		
AY	Trend	Loss Ratio			Loss Ratio		
2014	6.5%	**60.0%**			**63.9%**		
2015	6.0%	**60.0%**			**63.6%**		
2016	5.5%	**60.0%**			**63.3%**		
2017	5.0%	**60.0%**			**63.0%**		
2018	5.5%	**60.0%**			**63.3%**		
2019	4.5%	**60.0%**			**62.7%**		
2020	3.0%	**60.0%**			**61.8%**		
2021	0.0%	**60.0%**			**60.0%**		
2022	0.0%	**60.0%**			**60.0%**		

Same Market, Different Companies

		Company A			Company B		
AY	Trend	Loss Ratio	**Rate**		Loss Ratio	**Rate**	
2014	6.5%	60.0%	**6.5%**		63.9%	0.0%	
2015	6.0%	60.0%	**6.0%**		63.6%	**6.5%**	
2016	5.5%	60.0%	**5.5%**		63.3%	**6.0%**	
2017	5.0%	60.0%	**5.0%**		63.0%	**5.5%**	
2018	5.5%	60.0%	**5.5%**		63.3%	**5.0%**	
2019	4.5%	60.0%	**4.5%**		62.7%	**5.5%**	
2020	3.0%	60.0%	**3.0%**		61.8%	**4.5%**	
2021	0.0%	60.0%	0.0%		60.0%	**3.0%**	
2022	0.0%	60.0%	0.0%		60.0%	0.0%	

Same Market, Different Companies

		Company A			Company B		
AY	Trend	Loss Ratio	Rate	LR @ CL	Loss Ratio	Rate	LR @ CL
2014	6.5%	60.0%	6.5%	**60.0%**	63.9%	0.0%	**60.0%**
2015	6.0%	60.0%	6.0%	**60.0%**	63.6%	6.5%	**60.0%**
2016	5.5%	60.0%	5.5%	**60.0%**	63.3%	6.0%	**60.0%**
2017	5.0%	60.0%	5.0%	**60.0%**	63.0%	5.5%	**60.0%**
2018	5.5%	60.0%	5.5%	**60.0%**	63.3%	5.0%	**60.0%**
2019	4.5%	60.0%	4.5%	**60.0%**	62.7%	5.5%	**60.0%**
2020	3.0%	60.0%	3.0%	**60.0%**	61.8%	4.5%	**60.0%**
2021	0.0%	60.0%	0.0%	**60.0%**	60.0%	3.0%	**60.0%**
2022	0.0%	60.0%	0.0%	**60.0%**	60.0%	0.0%	**60.0%**

Implicit Assumption No. 4

New Book Resembles Renewal Book

- If trend is calculated on a portfolio level, effects emanating from changes in mix cannot be differentiated from true trend
- Deterioration in new business may manifest as increased trend
- These effects can be mitigated by:
  - Using technical adequacy to back out expected mix impacts
  - Calculating trend separately for new and renewal business
- But note that new business may structurally underperform renewal business, even in steady state → complicates analysis

Implicit Assumption No. 5

Rating Plan is Market Competitive

Illustration: Potential Commercial Auto Rating Factors

Driver	Vehicle	Company	Geography	Policy
Age	**Size / Type**	**Fleet Size**	**Territory**	**Deductible**
Gender	**Use**	**Industry (NAICS)**	**Operations Radius**	*Claims History*
Marital Status	**Model Year**	*Years in Business*	*Refined Territory*	*Package*
Credit Score	**Original Cost New**	*Credit Score*		*Tenure*
CDL History	*Mileage*	*Violation History*		*Telematics*
Violation History	*Symbol*	*Owner-Operator*		
Locality	*VIN*			
	Safety Features			
	Customizations			
	Personal Use			

Implicit Assumption No. 6

Expense Structure is Market Competitive

Expenses are (1) important and (2) self-reinforcing –

	Higher Expense	Lower Expense
Leads to . . .	lower required loss ratio	higher required loss ratio
Leads to . . .	higher average premium	lower average premium
Leads to . . .	market disadvantage	market advantage
Leads to . . .	lower premium	higher premium
Leads to . . .	higher expenses	lower expenses

Putting it All Together

When are all these true?

1. Business plans aren’t panning out
2. Management doesn’t seem to be executing
3. New business is lower quality than renewal business
4. Rating plan isn’t market competitive
5. Expenses aren’t market competitive
6. Loss ratio method doesn’t seem to work

Contrived Commercial Auto Example

	Company A	Company B
Starting Premium	X	>5X
Starting Loss Ratio	76.0%	80.5%
Expense Ratio (Variable)	17.0%	26.0%
Pricing Differentiation	Perfect	Perfectly Terrible (Equal Premium)
Trend Response	Perfect	Consistent 2% Underestimate

	Common Characteristics
Target Combined Ratio	93.0%
Loss Trend	10.0%
Insured Cohorts	10 cohorts with a 20% loss cost differential
Insured Elasticity	15% shop every year
Rate Change Calculation	Loss Ratio Method

Contrived Example – Results

	Company A Combined Ratio	Company A Rate Indication	Company B Combined Ratio	Company B Rate Indication
Year 1	93.0%	10.0%	102.0%	18.5%
Year 2	93.0%	10.0%	99.6%	15.6%
Year 3	93.0%	10.0%	98.8%	14.8%
Year 4	93.0%	10.0%	98.4%	14.3%
Year 5	93.0%	10.0%	98.3%	14.1%

	Company A	Company B
Premium Growth Rate	27.6%	6.6%

What Good is Rate Change?

Portfolio-level rate change can only ever do one of three things:

1. Counteract the impact of trend (including cumulative trend)
2. Extract excess profits from price-insensitive customers*
3. Surrender profits to increase or decrease market share*

Rate change can't achieve any objective not listed above.

* Not recommended.

On Major Adverse Selection Events

- The Loss Ratio Method can **only** recommend rate changes, and so **does not produce meaningful results** in a death spiral
- Consequences:
  - Pricing decisions for individual accounts are wrong
  - Booked loss ratios develop adversely
  - Management and investors get bad information
  - Resources are diverted from effective interventions (risk selection and expense control) to an ineffective intervention (portfolio rate change)

How Did We Get Here?

- This and similar methods were developed at a time when:
  - Rating plans were less sophisticated (few factors, no GLMs)
  - Rates and rating plans and had high homogeneity (bureaus)
  - Balance of value-add in a commercial portfolio was tilted more towards risk selection than towards risk pricing
  - Elasticity was lower due to the relative importance of local relationships and the relative difficulty of shopping around
  - Steeper cycles and cash flow underwriting were the norm
- Actuarial practice is insulated from competitive pressure

Mitigation (1 of 3)

- Perform separate trend studies for new and renewal business
- Keep an eye on the market:
  - Industry rate change (CIAB, CLIPS, IVANS, MarketScout)
  - Industry trend (ISO, CPI / PPI / Masterson)
  - Competitor activity (Rate filings, statutory filings)
  - . . . plus public company reporting, broker/consultancy reporting, and the insurance trade press for all of the above
- Actively investigate and report on signs of adverse selection
- Formalize this investigation and reporting as a checklist process

Mitigation (2 of 3)

- Adverse selection checklist (all of these are bad):
  - Loss Ratio Method fails backtest
  - Observed trend higher than industry trend
  - Rating plan less sophisticated than market
  - Expense ratio or profit provision higher than market
  - New business deteriorating relative to renewal business
  - Good business retained at lower rates than bad business
- Consider explicitly estimating the impact of adverse selection
- Consider methods that ignore internal rate and trend

Mitigation (3 of 3)

- Actively flag concerns to management
- Each of these are true much more often than they are said:
  - “Our rating plan isn’t sophisticated, and so I don’t expect rate change to produce a dollar-for-dollar benefit.”
  - “We haven’t been executing, and I need to dock us for that.”
  - “Our combined premium and rate targets are too aggressive. If we somehow manage to hit them, the loss ratio will suffer.”
  - “My indicated rate change isn’t meaningful. There’s no rate change that will return this book to profitability next year.”

Final Commercial Auto Example

	Company A	Company B
2016 Auto Direct Written Premium	X	>5X
2016-21 Written Premium Growth	27.9%	7.8%
AY 2017-21 Loss and DCC Ratio	75.9%	81.7%
AY 2017-21 Expense Ratio	17.2%	25.7%
AY 2017-21 Combined Ratio	93.1%	107.4%

Final Commercial Auto Example

	Company A	Company B
2016 Auto Direct Written Premium	X	>5X
2016-21 Written Premium Growth	27.9%	7.8%
AY 2017-21 Loss and DCC Ratio	75.9%	81.7%
AY 2017-21 Expense Ratio	17.2%	25.7%
AY 2017-21 Combined Ratio	93.1%	107.4%
2021 Auto Direct Written Premium	$6.9B	$15.6B
2021 Total Direct Written Premium	$48.3B	$306.3B

Final Commercial Auto Example

	Company A	Company B
2016 Auto Direct Written Premium	X	>5X
2016-21 Written Premium Growth	27.9%	7.8%
AY 2017-21 Loss and DCC Ratio	75.9%	81.7%
AY 2017-21 Expense Ratio	17.2%	25.7%
AY 2017-21 Combined Ratio	93.1%	107.4%
AY 2017-21 Adverse Development	5.1%	5.6%
2021 Auto Direct Written Premium	$6.9B	$15.6B
2021 Total Direct Written Premium	$48.3B	$306.3B
AY 2017-21 Adverse Development	5.1%	5.6%
Credentialed Actuaries on Payroll	19	~1900

Part 2

Innovation:

A Rate-Agnostic Bayesian Approach

How Can We Model This?

- It would be nice to know if we're in a death spiral
- Root cause of death spirals is adverse selection
- Adverse selection is difficult to isolate

Illustration: A Simple Example

On-Leveled Hist LR	64.0%
Trend Selection	5.5%
Rate Selection	8.0%
Projected LR	62.5%
Achieved LR	68.0%
LR Forecast Error	**+5.5%**

Illustration: A Simple Example

LR Forecast Error	**+5.5%**
Trend Error	+2.0%
UW Effect Error	+1.0%
Dev Factor Error	+1.5%
Distribution Mix Error	+0.5%
Weather Error	+0.5%
Total Explained Error	**+5.5%**

Adverse Selection is Slippery!

- Individual Examples → Individual Hypotheses
- Always another alternative theory to test
- Solution: don’t test individual examples

An Aggregate Approach to Modeling

- Simple insight: Loss ratio method failure → Adverse selection
- Test Loss ratio method by backtesting ourselves:
  - Take *many* historical internal loss ratio projections
  - Diversify across time, geography, product line, motivation
  - Measure difference between projected and actual LR
- Is there a systemic bias in projected LRs?
  - No? Congratulations!
  - Yes? Two options:
    - You're in a death spiral
    - You're bad at projections

Practical Obstacles to This Approach

- Internal loss ratio forecasts can be hard to collect
  - Even for internal parties
- Corpus of historical forecasts can be small
- Actual LRs are themselves estimates
- Analysis of results can be difficult
- Red flag pattern to check for:
  - Bigger rate changes → bigger biases? Adverse selection!

An Outsider’s Approximation

- We don’t have access to company-internal information
- We do have access to statutory filings
  - Pros:
    - Earned premium by company and LOB
    - Loss triangles by company and LOB
  - Cons:
    - No exposure
    - No rate
    - No forecasts of future performance

Outsider Model

- Use Chain-Ladder to develop 10 years of reported losses
- Use historical average incurred/reported ratio at 10 years for tail factor
- Feed historical loss ratios into a Bayesian state-space model
  - Weighted by earned premium
  - Cape-Cod adjustment
  - Assume damped momentum of loss ratio trends
  - Assume mild reversion to long-run means
  - Include external predictor: Industry average loss ratios
- Predict next year's loss ratio

Insider’s Model

- For each year, take incurred loss ratio at dev lag 0 years
- Predict incurred loss ratio for same year at dev lag 10 years

Outsider vs Insider Comparison

- Compare outsiders and insiders on statutory data
  - Four liability-centric lines of business
    - Workers' Compensation
    - Private Auto Liability
    - Commercial Auto Liability
    - Other Liability – Occurrence
  - Companies and groups with >$50M net earned premium
  - Predictions for AY 1997-2012
- Compare performance via predicted RMSE

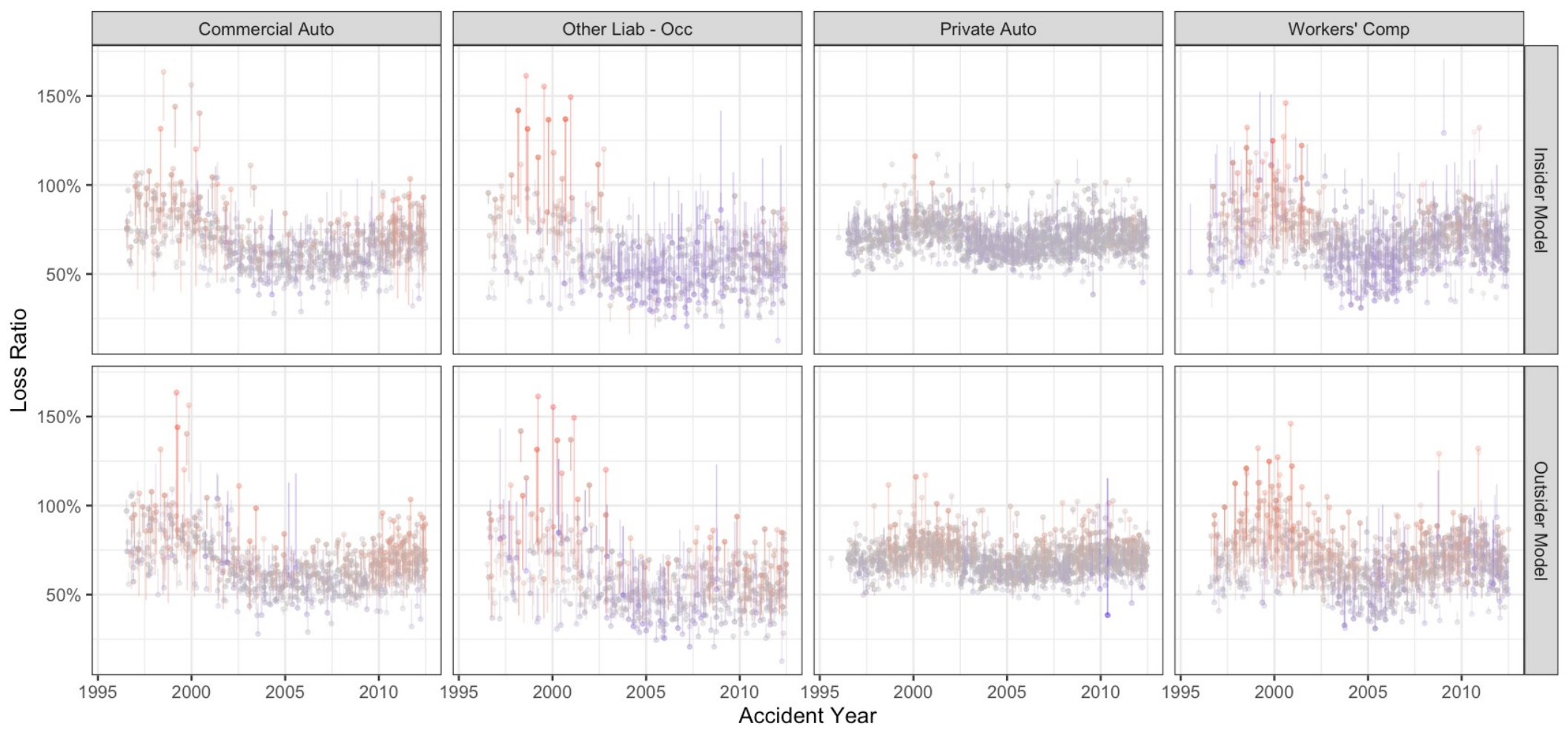
Outsider vs Insider Comparison

- Not fair comparison, but best available proxy
  - Insiders get an extra year of premium and loss data
  - Outsiders have to do loss development
  - Outsiders have no knowledge of rate, underwriting, etc
  - Insiders may not be pricing actuaries
  - Insiders may not be measuring same thing
- If outsiders outperform insiders, interesting result!

Outsider vs Insider Results

Prediction Error (RMSE)	**Outsiders**	**Insiders**
Workers' Compensation	13.8%	14.4%
Commercial Auto Liability	13.0%	12.6%
Private Passenger Liability	7.7%	6.4%
Other Liability - Occurrence	17.4%	17.8%

Outsider vs Insider Results



Outsider vs Insider Conclusions

- Outsider wins on long-tailed lines
- Insider wins on short-tailed lines
  - Most recent year more valuable on short-tailed lines
- Outsider model has no knowledge of an insurer's plans
- Insider models know exact exposure and rate achieved
- Should have been an insider blowout!
- Suggests room for improvement in internal loss ratio forecasts

Questions?