Session 085: Mortality Improvement Series Part 1: What is Currently Being Done?

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2019 ANNUAL MEETING & EXHIBIT

Mortality Improvement Series Part 1:

Life and Annuity Mortality Improvement Practices Survey – The Results (Session 85)

Al Klein, FSA, MAAA

Principal and Consulting Actuary, Milliman

Date: October 29, 2019

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Background and Overview

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Background

- SOA conducted a survey on mortality improvement practices and rates in early 2019
- Survey was conducted by a subcommittee of the Mortality and Underwriting Survey Committee of the SOA
- Survey Subcommittee:
  - Al Klein, Chair, U.S. Actuary
  - Connie Dewar, Canadian Actuary
  - Mark Dion, U.S. Underwriter
  - David Wylde, U.S. Actuary
- Others to recognize for their help with this project:
  - Hannah Lobbezoo
  - Cindy MacDonald
  - Pete Miller
  - All of the participants

Overview

- 42 companies responded, results will be split by:
  - Country (Canada and U.S.)
  - Company type (Direct and Reinsurer)
  - Product (Life and Annuity)
  - Projection type (Pricing and Financial projections)
- For confidentiality reasons, some combinations of splits will be limited
- Company opinions were also asked on a number of items
  - Some will be covered here
  - Full report will provide more details and some other items, e.g., opinions on the future of e-cigarettes, and Accelerated Underwriting
- Results presented here are preliminary and final results in paper will likely be slightly different

Agenda

1. Survey Basics
2. Durational Mortality Improvement Practices
3. Durational Mortality Improvement Opinions
4. Generational Mortality Improvement Practices
5. Durational Mortality Improvement Rates
6. Concluding Thoughts

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Survey Basics

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Distribution of responding companies

42 companies responded

TYPE OF COMPANY	COUNTRY		
	CANADA	U.S.	Total
Direct	4	30	34
Reinsurer	3	5	8
Total	7	35	42

Distribution of responding companies

42 companies responded

TYPE OF PRODUCT	COUNTRY		
	CANADA	U.S.	TOTAL RESPONDING
Life	7	34	41
Annuity	3	27	30
Total Possible	7	35	42

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Durational Mortality Improvement Practices

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Durational Mortality Improvement

"Durational mortality improvement describes the process of projecting the current era's mortality into the future.
As a cohort proceeds in time from policy year to policy year, the mortality rates applicable in each year may be lower than defined by the base mortality table selected for the project.
Durational mortality improvement is a way of keeping the annual mortality rate of a cohort up-to-date by applying future trends or expectations for mortality improvement."

Companies using Durational Mortality Improvement

42 companies responded, 34 use durational mortality improvement

TYPE OF COMPANY	COUNTRY		
	CANADA	U.S.	Total
Direct	2	25	27
Reinsurer	3	4	7
Total	5	29	34

Distribution of responding companies

42 companies responded

TYPE OF PROJECTION	TYPE OF PRODUCT	
	LIFE	ANNUITY
Pricing	32	18
Financial Projection	30	21
Total Possible	34	34

Characteristics of Durational Mortality Improvement Program (Part 1)

NUMBER OF COMPANIES				
CHARACTERISTIC	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Attained Age	24	23	16	19
Gender	22	20	15	17
Duration	15	12	3	3
Smoking Status	12	10	0	0
Product	3	3	2	3
Issue Age	3	3	0	0
Year-of-birth Cohort	2	2	2	2
Face Amount	2	2	0	0
Risk Class	1	0	0	0

Characteristics of Durational Mortality Improvement Program (Part 2)

NUMBER OF COMPANIES				
CHARACTERISTIC	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Other				
Benefit Amount	-	-	-	1
Calendar Year	5	4	3	5
Constant amount applied for 20 years regardless of issue age, gender, etc.	1	1	-	-
Generational	-	-	1	1
Issue year cohorts are different for older blocks of business than newer blocks	1	1	-	-
Socioeconomic Factors	1	1	1	1
Underwriting Type	1	1	1	1
Total Respondents	29	25	17	20

Limitations on Durational Mortality Improvement Program

ATTAINED AGE				
MEASURE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Minimum				
Low	0	0	0	0
Average	9.6	10.4	3.8	3.2
High	35	35	20	20
Most common	0 (10)	0 (8)	0 (8)	0 (10)
Maximum				
Low	89	89	99	99
Average	102.0	102.4	109.3	110.7
High	121	121	150	150
Most common	100 (5)	100 (4)	103, 104 (3 ea.)	103, 104 (3 ea.)

Limitations on Durational Mortality Improvement Program

ANNUAL MORTALITY IMPROVEMENT RATE				
MEASURE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Minimum				
Low	0 %	- 0.12 %	0 %	0 %
Average	0.14	0.13	0.05	0.12
High	0.5	0.75	0.3	0.5
Most common	0 (10)	0 (8)	0 (8)	0 (8)
Maximum				
Low	0.5	0.7	1	1
Average	1.36	1.38	1.44	1.58
High	2.69	2.69	1.5	2.69
Most common	1 (7)	1.5 (5)	1.5 (7)	1.5 (7)

Limitations on Durational Mortality Improvement Program

MAXIMUM NUMBER OF YEARS USED				
MEASURE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Low	15	15	10	20
Average	17.1	18.5	57.7	75.9
High	125	125	104	125
Most common	20 (12)	20 (10)	All unique	All unique
Total Respondents	21	17	6	7

Data Used for Determining Durational Mortality Improvement

NUMBER OF COMPANIES				
DATA SOURCE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Population data	20	16	8	11
Industry data	19	15	11	12
Company's data	14	12	1	2
Government data	12	7	5	5
Other				
CIA PfAD	-	1	-	1
Consultant Recommendation	1	1	-	-
Life was just a mgmt. decision	1	1	-	-
Projection Scale G2 (Industry table)	-	-	1	-
Reinsurer	1	1	-	-
Reinsurer's data	1	1	-	-
Total Respondents	31	26	16	19

Resources Used to Develop Durational MI Assumptions

NUMBER OF COMPANIES				
RESOURCE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Internal	29	26	16	20
Reinsurer / Retrocessionaire	9	6	0	0
Consultant	8	8	2	2
Other				
CIA industry scale	1	1	1	2
CPP	1	-	1	1
Industry study/developed	-	-	1	1
Industry table	-	-	1	-
SOA	-	-	1	1
SOA industry study	1	1	-	-
Total Respondents	29	26	17	20

Internal Resources Used to Develop Durational MI Assumptions

NUMBER OF COMPANIES				
INTERNAL RESOURCE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Actuary(ies)	25	26	16	20
Committee	9	10	7	8
Senior Officer(s)	8	6	6	7
Medical Director(s)	7	8	2	2
Data Scientist(s)	3	4	0	0
Underwriter(s)	1	2	1	1
Other				
Risk team	1	1	1	1
Peer Review Committee	1	-	-	-
Total Respondents	29	26	16	20

Standard Approach Used to Develop Durational MI Assumptions

NUMBER OF COMPANIES				
STANDARD APPROACH	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
No Standard Approach	13	11	4	4
Other Standard Approach	9	8	7	7
CIA MI -2017	3	2	2	3
RPEC	1	1	1	2
Lee-Carter	1	1	0	0
CMI (2009 or 2016)	0	0	0	0
Total Respondents	27	23	14	16

Other Approaches Used to Develop Durational MI Assumptions

OTHER STANDARD APPROACH	NUMBER OF COMPANIES
Annual update with most recent MP scale	1
CMI and Human Mortality Database	1
Company experience and credibility theory	1
Constant compounded rate by duration, varying by AA and gender to max AA	1
Consultant recommendations, one with heavier emphasis on recent years	2
CPP	1
Cubic interpolation	1
Industry study	2
Internal, one indicated of APCI model	3
Lee-Carter (time weighted)	2
Linear interp. between short (10) and long term (25 years) applied in durations 1 & 20	1
Scale G2 and variations of it	6
SOA research (life)	2
TOAMS III	1
US CMI	1
US general population by age group, with adjustments for ins. or older age	3
Not sure if Standard	1
Total Respondents	28

Standard Approaches Used to Develop Durational MI Assumptions

- **CIA:** Canadian Institute of Actuaries. The CIA has developed at least two projection models.
- **CMI:** Continuous Mortality Investigations. These projection models were developed in the UK and are used in a number of countries. There are at least two CMI projection models.
- **RPEC:** Retirement Plans Experience Committee of the SOA. Starting in 2014, RPEC has released annual updated mortality improvement scales, each based on the underlying RPEC_2014 model.

Changes to Durational MI Assumptions from recent slowing of MI

NUMBER OF COMPANIES				
TYPE OF CHANGE	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Decrease all assumptions	4	2	0	2
Decrease limited number of assumptions	2	2	3	4
Extrapolate only most recent past experience	1	1	0	0
Other				
Applied a cap to the assumptions	-	1	-	-
By future projection year	1	1	-	-
Choose conservative assumptions	1	1	-	-
Do not reflect most recent past experience	1	1	-	1
Update assumptions regularly using same method	2	2	-	-
Weighted recent experience more heavily	1	1	1	1
Total Respondents	13	12	4	8

Validation of Durational MI Assumptions

NUMBER OF COMPANIES				
Validate?	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Yes	16 (64%)	15 (65%)	3 (21%)	4 (25%)
No	9	8	11	12
Total Respondents	25	23	14	16

Review of Durational MI Assumptions (Part 1)

NUMBER OF COMPANIES				
When?	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Every year	7	9	5	5
Over 1 year and up to 3 years	7	6	2	4
Over 3 years	3	3	0	1
As product is priced or repriced	5	2	3	2
As new population mortality data is published	3	3	1	1
As new insured mortality data is published	0	0	0	0
As needed	3	3	3	5

Review of Durational MI Assumptions (Part 2)

NUMBER OF COMPANIES				
When?	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Other				
Every 2 years	2	2	2	2
Began producing assumptions in 2018	1	1	-	-
Reviewed as part of new product pricing and development process	1	1	1	1
Updated whenever industry table updated	-	-	1	-
Total Respondents	32	30	18	21

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Durational Mortality Improvement Opinions

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Top 3 Challenges to Setting MI Assumptions

CHALLENGE	RANK			
	1	2	3	Weighted Rank
Uncertainty of magnitude of future trends	11	10	4	57
Availability of appropriate data	11	4	6	47
Uncertainty in direction of future trends	9	5	3	40
Differences in underwriting over time	3	4	6	23
Determining age/period/cohort effects	0	7	8	22
Limited resources	2	3	5	17
Difficulty in backtesting models	0	2	2	6
Modeling uncertainty	0	1	2	4

Drivers of Future Mortality Improvement

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Top 5 Drivers of Future Mortality Improvement (Life Short Term)

DRIVER: LIFE SHORT TERM (5-10 YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Reductions in mortality from cancer	16	12	3	3	1	144
Reductions in mort from cardiovascular disease	8	10	4	0	2	94
Medical advances	6	3	2	6	6	66
Access to healthcare/medical care	5	1	2	4	2	45
Improvements in healthcare/medical care	2	1	6	3	4	42
Advances in underwriting methodologies	1	3	2	4	3	34
Healthier lifestyle behaviors	1	2	3	4	1	31
Advances in understanding of genetics	0	3	1	5	1	26
Advances in understanding of aging	0	0	5	0	4	19
Reductions in mort from Alzheimer[s disease	0	1	2	4	0	18
Precision medicine	0	1	2	2	4	18

Top 5 Drivers of Future Mortality Improvement (Ann. Short Term)

DRIVER: ANNUITY SHORT TERM (5-10 YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Reductions in mortality from cancer	7	6	1	2	0	66
Reductions in mort from cardiovascular disease	5	3	3	0	1	47
Access to healthcare/medical care	3	2	1	3	0	32
Improvements in healthcare/medical care	1	2	4	2	3	32
Medical advances	1	0	2	6	5	28
Healthier lifestyle behaviors	3	0	3	1	1	27
Changes in government programs/policy	1	2	3	4	1	14
Precision medicine	0	1	2	1	0	12
Advances in underwriting methodologies	0	2	0	1	1	11
Advances in understanding of aging	1	0	1	0	2	10
Advances in understanding of genetics	0	2	0	0	2	10

Top 5 Drivers of Future Mortality Improvement (Life Long Term)

DRIVER: LIFE LONG TERM (20+ YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Reductions in mortality from cancer	11	7	5	6	0	110
Medical advances	13	0	6	4	2	93
Advances in understanding of genetics	5	9	5	6	1	89
Advances in the understanding of aging	2	6	4	3	8	60
Reductions in mort from cardiovascular disease	3	7	2	2	2	55
Reductions in mort from Alzheimer's disease	0	2	4	3	2	28
Improvements in healthcare/medical care	1	2	2	1	4	25
Healthier lifestyle behaviors	1	0	4	2	3	24
Access to healthcare/medical care	0	2	3	1	2	22
Precision medicine	1	0	0	4	6	19

Top 5 Drivers of Future Mortality Improvement (Ann. Long Term)

DRIVER: ANNUITY LONG TERM (20+ YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Reductions in mortality from cancer	6	4	2	4	0	60
Medical advances	5	1	5	3	1	51
Advances in understanding of genetics	4	5	1	2	1	48
Advances in the understanding of aging	2	1	3	3	5	34
Healthier lifestyle behaviors	2	0	4	1	2	26
Reductions in mort from cardiovascular disease	2	2	1	1	1	24
Improvements in healthcare/medical care	0	3	2	0	4	22
Reductions in mort from Alzheimer's disease	0	2	0	4	2	18
Precision Medicine	1	1	1	1	2	16
Access to healthcare/medical care	1	1	1	1	0	14

Mortality Improvement choices that didn't make the top 10 on any of the four lists (plus the Other comments)

- Artificial Intelligence/Augmented Reality
- Fitness tracking
- Reductions in level of stress leading to improved mortality
- Reductions in socioeconomic differences
- Self driving cars
- Technological advances

- Other comment: Wellness/Preventive programs

Drivers of Future Mortality Deterioration

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Top 5 Drivers of Future Mortality Deterioration (Life Short Term)

39 companies responded, 1 company did not provide a rank for 5

DRIVER: LIFE SHORT TERM (5-10 YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Opioids	19	2	8	2	2	133
Obesity	6	10	4	3	5	93
Diabetes	4	6	3	3	2	61
Mental health/depression	0	5	3	4	2	39
Lifestyle behaviors	2	2	3	4	2	37
Alzheimer's/dementia	0	3	4	2	2	30
Changes in government programs/policy	2	2	0	2	3	25
Socioeconomic inequality	1	1	1	3	5	23
Suicides	0	1	4	2	1	21
Antibiotic resistant organisms	0	2	2	4	1	20

Top 5 Drivers of Future Mortality Deterioration (Ann. Short Term)

22 companies responded, 1 company did not provide a rank for 5

DRIVER: ANNUITY SHORT TERM (5-10 YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Opioids	9	4	3	0	1	71
Diabetes	3	3	3	3	1	43
Obesity	1	6	2	0	5	40
Lifestyle behaviors	2	1	3	1	2	27
Changes in government programs/policy	1	2	2	1	1	22
Mental health/depression	0	1	1	5	1	18
Socioeconomic inequality	2	1	0	1	1	17
Cardiovascular disease	1	0	3	0	0	14
Cancer	0	0	2	3	0	12
Accidents	2	0	0	0	0	10

Top 5 Drivers of Future Mortality Deterioration (Life Long Term)

DRIVER: LIFE LONG TERM (20+ YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Obesity	9	9	5	1	4	102
Antibiotic resistant organisms	7	2	4	2	5	64
Lifestyle behaviors	4	4	3	5	4	59
Mental health/depression	1	4	6	4	4	51
Diabetes	4	3	1	2	3	42
Socioeconomic inequality	2	2	1	5	4	35
Opioids	3	0	3	2	1	29
Pollution	1	1	3	3	2	26
Chemicals and hormones in the environment	2	3	0	1	1	25
Changes in government programs/policy	2	0	2	4	1	25

Top 5 Drivers of Future Mortality Deterioration (Ann. Long Term)

DRIVER: ANNUITY LONG TERM (20+ YEARS)	RANK					
	1	2	3	4	5	Wt'd Rank
Obesity	3	5	3	1	4	50
Antibiotic resistant organisms	3	2	3	1	1	35
Lifestyle behaviors	3	2	0	3	4	33
Mental health/depression	0	3	4	2	1	29
Socioeconomic inequality	2	1	1	5	1	28
Diabetes	4	0	0	0	2	22
Opioids	2	0	3	1	0	21
Chemicals and hormones in the environment	1	3	0	0	1	18
Smoking/vaping	1	1	1	2	0	16
Pollution	0	1	3	1	0	15

Mortality Deterioration choices that didn't make the top 10 on any of the four lists (plus the Other comments)

- Catastrophes
- Epidemics/pandemics
- Homicides
- Medical errors
- Smoking/vaping
- Stress
- Terrorist activities

Other comments:

- Automated underwriting misrepresentation
- Climate change
- DNA legislation
- HIV legislation

General population mortality improvements have slowed in recent years. Indicate if you believe this trend will reverse or continue into the future.

40 companies responded

PERIOD	REVERSE	CONTINUE
Short term (5-10 years)	10	30
Long term (20+ years)	26	14

Responses from Canada favored a trend that would reverse both short and long term

Opinion on Improvement or Deterioration, Short and Long Term, on Cardiovascular and Cancer Mortality

40 companies responded

	CARDIOVASCULAR		CANCER	
DIRECTION	SHORT TERM (5-10 YEARS)	LONG TERM (20+ YEARS)	SHORT TERM (5-10 YEARS)	LONG TERM (20+ YEARS)
Large deterioration	0	0	0	0
Moderate deterioration	1	1	1	0
Small deterioration	3	4	2	2
No improvement or deterioration	10	3	4	8
Small improvement	23	21	21	19
Moderate improvement	3	11	9	11
Large improvement	0	0	3	11
Total Respondents	40	40	40	40

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Generational Mortality Improvement Practices

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Generational Mortality Improvement

"Generational mortality improvement describes the process of bringing historical mortality experience up to the current era. For example, if an actuary has an experience study from an observation period ending several years ago, he or she might want to trend that experience to account for any mortality improvement from the observation period to the current projection date."

How Generational MI Assumptions Compare to Durational MI

NUMBER OF COMPANIES				
GENERATIONAL MI ASSUMPTIONS ARE:	LIFE PRICING	LIFE PROJECTION	ANNUITY PRICING	ANNUITY PROJECTION
Same	13	14	11	11
Higher	3	4	0	1
Lower	0	0	0	1
Higher and lower, depending on cell	7	8	4	5
Do not use generational MI	5	4	2	2
Total Respondents	28	30	17	20

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Durational Mortality Improvement Rates

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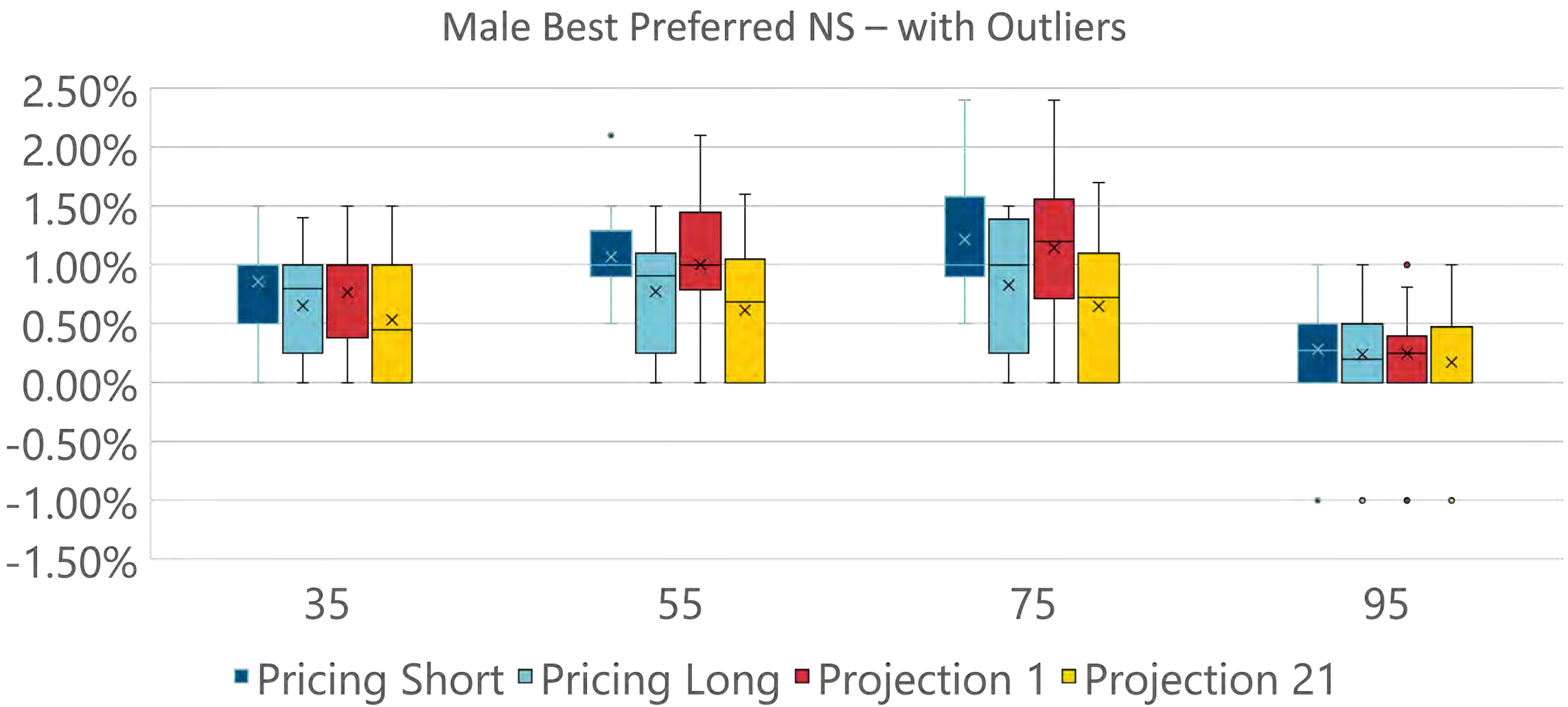
Durational MI Rates Requested

- Attained ages: 35, 55, 75, 95
- Products: Life, Annuities
- Type: Pricing, Financial Projections
- Period:
  - For pricing: Short-term, Long-term
  - For financial projections: Year 1, Year 21
- Category:
  - For life: Male and Female best preferred NS and residual standard NS
  - For annuities: Male and Female

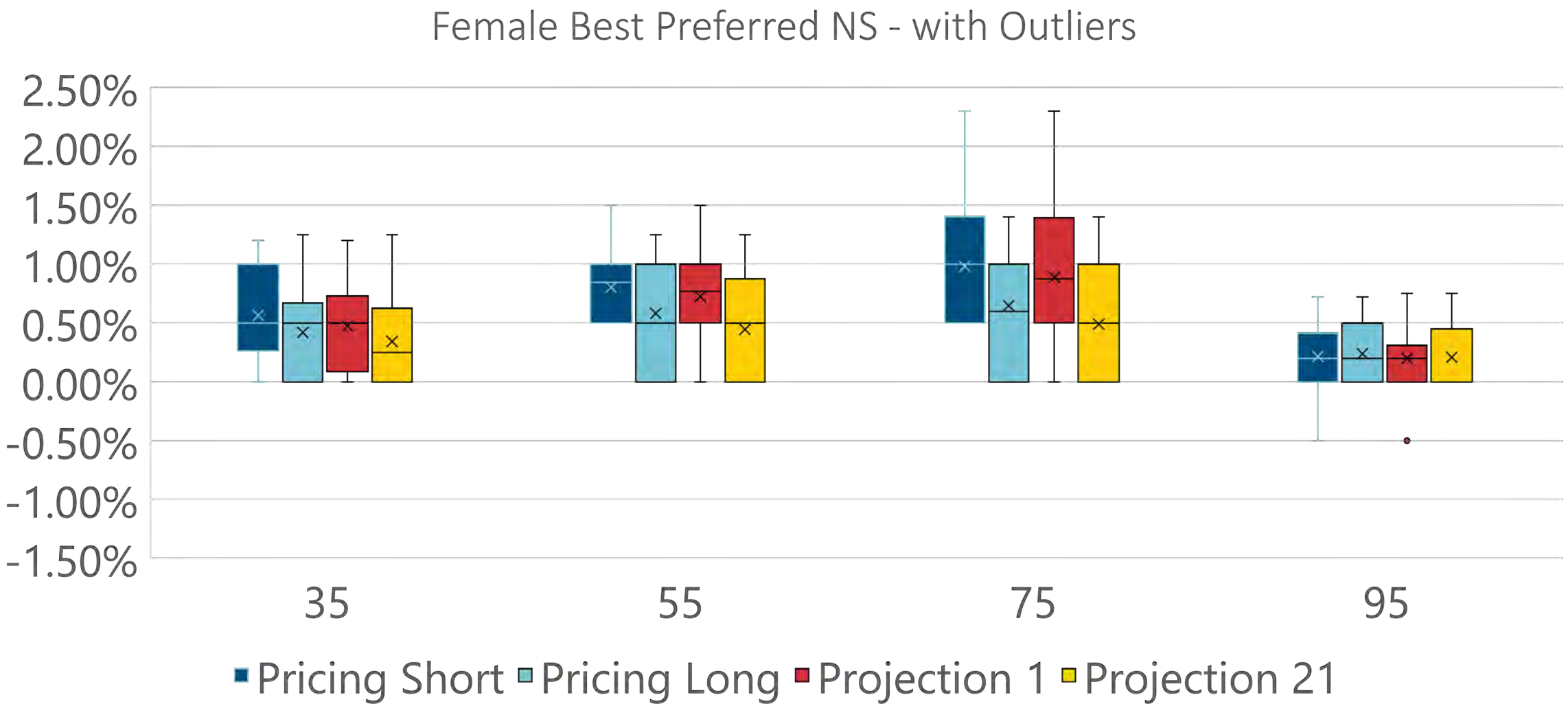
Durational MI Rates Shown

- Data shown:
  - Life best preferred NS and annuity
  - For all ages and pricing and financial projection periods
  - Separately for males and females
- "Box and Whiskers" graphs show:
  - x represents average
  - Lines represent maximum, median, and minimum
  - Box shows top of 2nd quartile and bottom of 3rd quartile

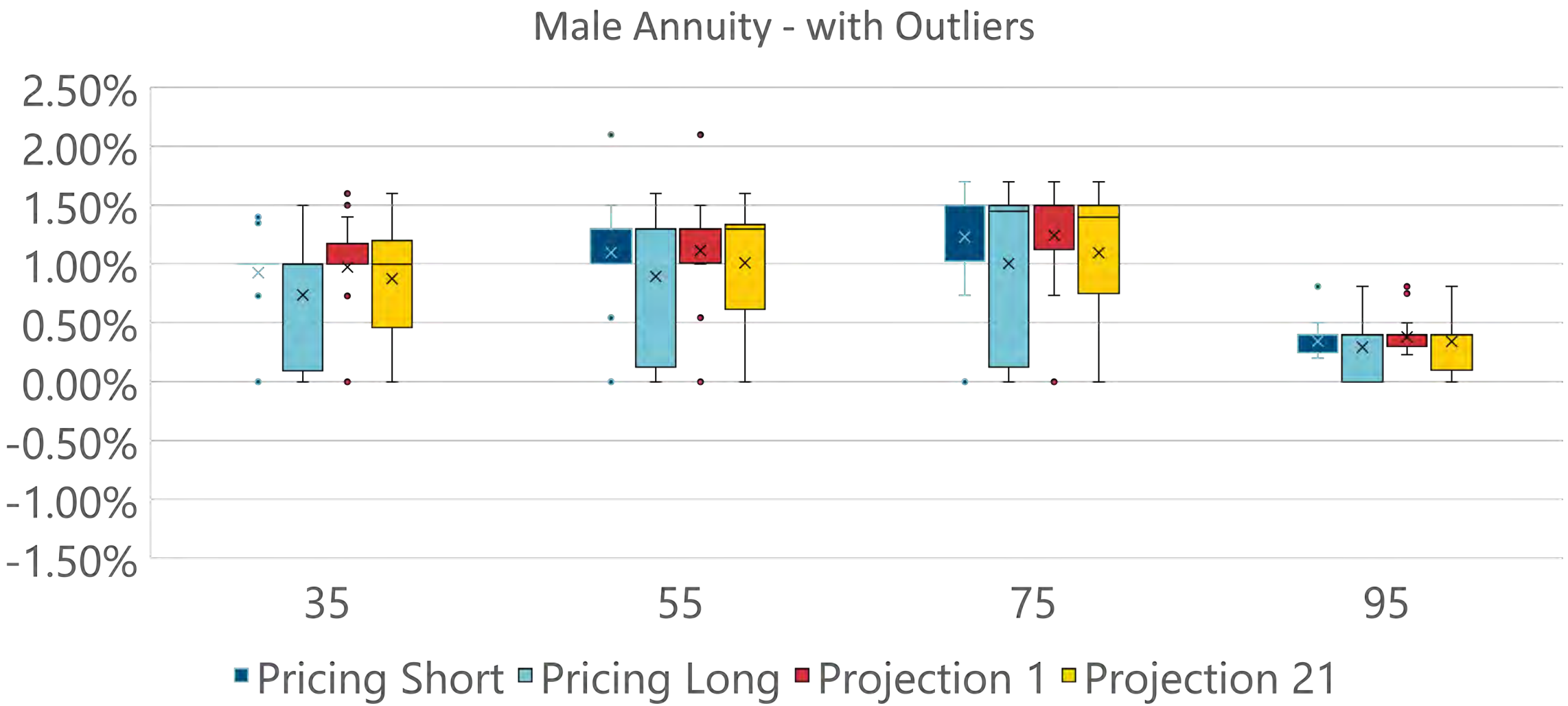
Male Life Best Preferred Nonsmoker



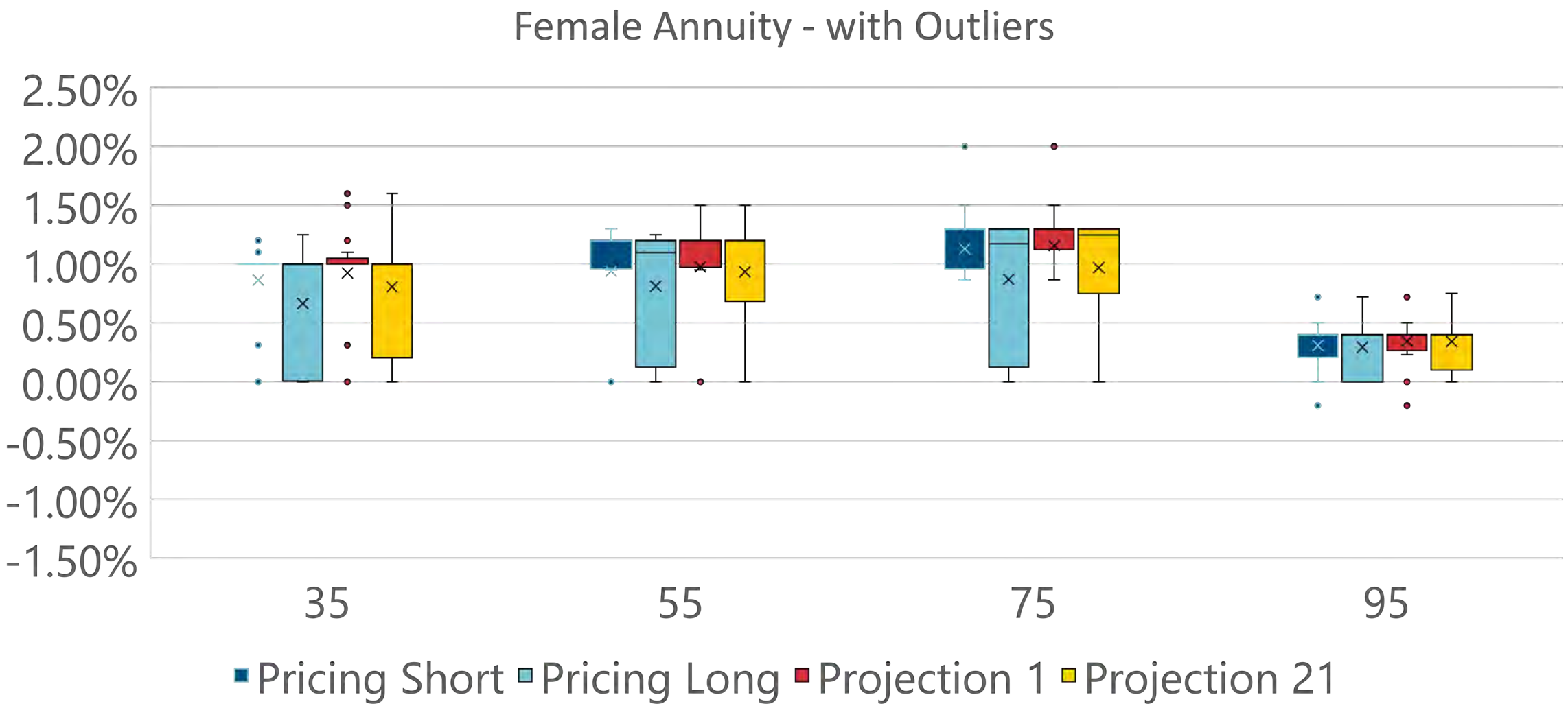
Female Life Best Preferred Nonsmoker



Male Annuity



Female Annuity



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Concluding Thoughts

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Tying the two presentations together

- While there are standard approaches to developing mortality improvement assumptions in Canada and the UK, currently there are no consistent practices for determining mortality improvement assumptions in the US among:
  - Pensions
  - Life
  - Annuities
  - Pricing
  - Valuation
- The SOA is in the process of building a consistent framework for all U.S. actuaries to use for building mortality improvement assumptions

Tying the two presentations together (cont'd)

- You will hear more about this consistent framework next year at the Life and Annuity Symposium and I believe also at the annual meeting
- The methodology will be similar to, but not the same as what you heard Patrick describe in his presentation as we started with the RPEC approach
  - It will also be similar to but different than both the Canadian approach and CMI
- While the intent is for actuaries to use this consistent framework, there will be much flexibility in it and we would expect all actuaries to be able develop appropriate rates for their particular practices

Tying the two presentations together (cont'd)

- There is a session 107 (Mortality Improvement Series – Part 2: What is the Latest Research) at 10:15 which will explain some of the research we contracted to help us build this consistent framework
- Again, watch for more on this consistent framework next year

Milliman

Thank you

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Questions?

Bio – Al Klein

- Principal and Consulting Actuary, Milliman, Buffalo Grove (Chicago), IL, since 2009
- Responsible for industry experience studies at Milliman, mortality/longevity/life underwriting consulting, helping InsurTech companies enter the life insurance marketplace
- Frequent national and international speaker on many topics
- SOA activities: Chair of Underwriting Issues and Innovation Seminar planning committee, Chair of Accelerated Underwriting Practices and Mortality Improvement surveys, Chair of POG for Economic Costs of Opioid Epidemic paper, Member of Mortality and Longevity Steering Committee, Consistent Framework for Mortality Improvement Assumptions Team, Actuaries Longevity Illustrator Team, WILL (Workable Innovations for Living Longer) Contest Team, Mortality and Underwriting Survey Committee, 2015 Valuation Basic Table team
- Other activities: Co-Vice Chair of the International Actuarial Association Mortality Working Group, Chair of MWG Research Projects Team, Drivers of Future Mortality and Underwriting Around the World research projects, Member of Longer Life Foundation Advisory Board
- Awards: One of 2017 SOA Volunteers of the Year, Best paper for 2018 SOA Product Development Section contest on creative presentation of future technologies, SOA Outstanding Presentation awards in 2016 and 2018
- Article: “Will You Live Longer?”, The Actuary, August/September 2019
- Bachelor of Science degree in Actuarial Science and Finance, University of Illinois, Champaign/Urbana
- Contact information: al.Klein@milliman.com, 312-499-5731

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Session 085: Mortality Improvement Series Part 1: What is Currently Being Done?

Patrick Nolan, FSA, MAAA

October 29, 2019

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- Do not discuss what you or other entities plan to do in a particular geographic or product markets or with particular customers.
- Do not speak on behalf of the SOA or any of its committees unless specifically authorized to do so.
- Do leave a meeting where any anticompetitive pricing or market allocation discussion occurs.
- Do alert SOA staff and/or legal counsel to any concerning discussions
- Do consult with legal counsel before raising any matter or making a statement that may involve competitively sensitive information.

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2019 ANNUAL MEETING & EXHIBIT

Background and Data

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Background

- Earlier this decade, SOA and the Retirement Plans Experience Committee (RPEC) sought to update old pension mortality assumptions
  - Most recent base table: RP-2000 (data midpoint of 1992)
  - Most recent mortality improvement scale: Scale AA (released in 1994)
- In 2014, released the RP-2014 Mortality Tables (data midpoint of 2006)
- Question: How to project mortality improvement forward from 2006?

Background

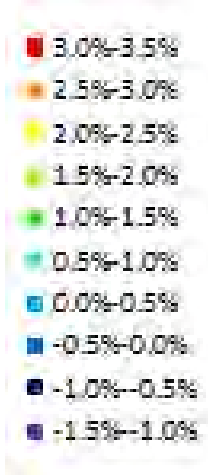
- Scale AA is a “one-dimensional” mortality improvement scale; one mortality improvement rate for every age.
- Continuous Mortality Investigation (CMI) in the U.K. had been modeling mortality improvement on a two-dimensional (age/calendar year) scale
  - Observed “cohort effects”, in which members of a particular year-of-birth cohort tend to experience particularly high or low mortality improvement over time
  - Observed “period effects”; periods of high or low mortality improvement across consecutive calendar years
  - Led RPEC to explore a two-dimensional mortality improvement scale for the U.S.

Data Sources

- Credible mortality improvement data requires large quantities of consistent data over long periods of time
  - Not feasible to collect a suitable pension dataset
- RPEC turned to Social Security Administration (SSA) historical probabilities of death
  - Historical rates graduated by age within individual calendar years
  - Rates computed from data furnished by:
    - Centers for Disease Control and Prevention (CDC)
    - Centers for Medicare and Medicaid Services (CMS)
    - Census Bureau
- Graduated historical improvement data using two-dimensional Whittaker-Henderson graduation

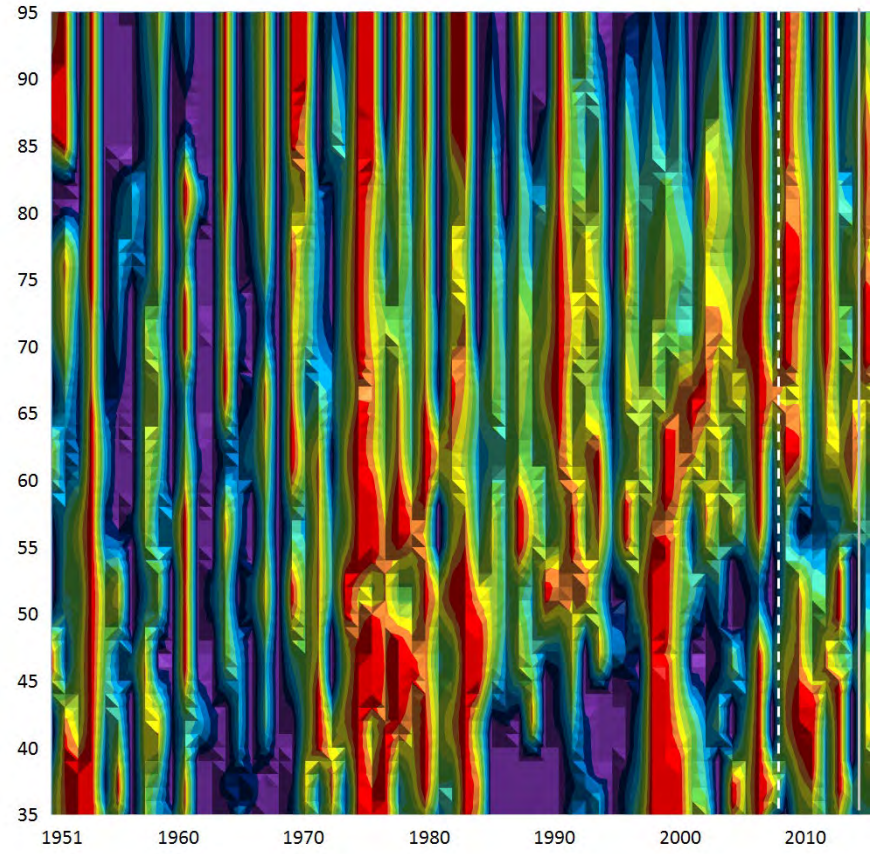
Data Sources

- Historical U.S. mortality improvement analyzed using “heat maps”
- Pictures use “hot” colors for high mortality improvement and “cold” colors for low mortality improvement:



Ungraduated Historical Mortality Rates

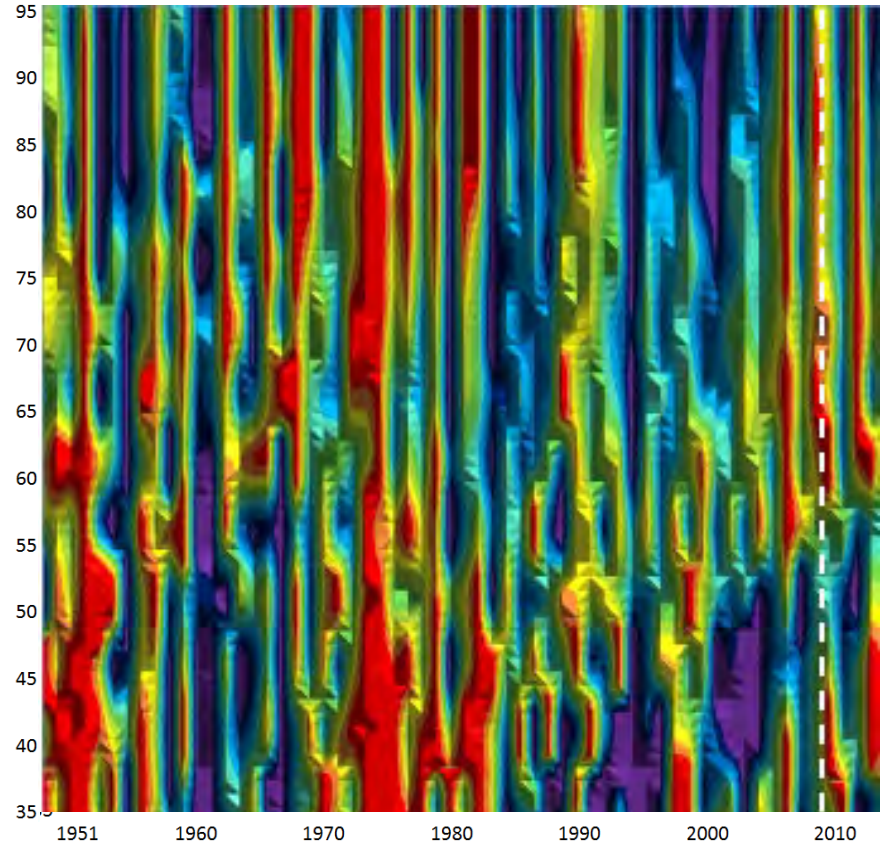
Male Mortality Improvement



- Volatility makes patterns difficult to identify in the ungraduated experience
- Cohort effects are still visible even without graduation

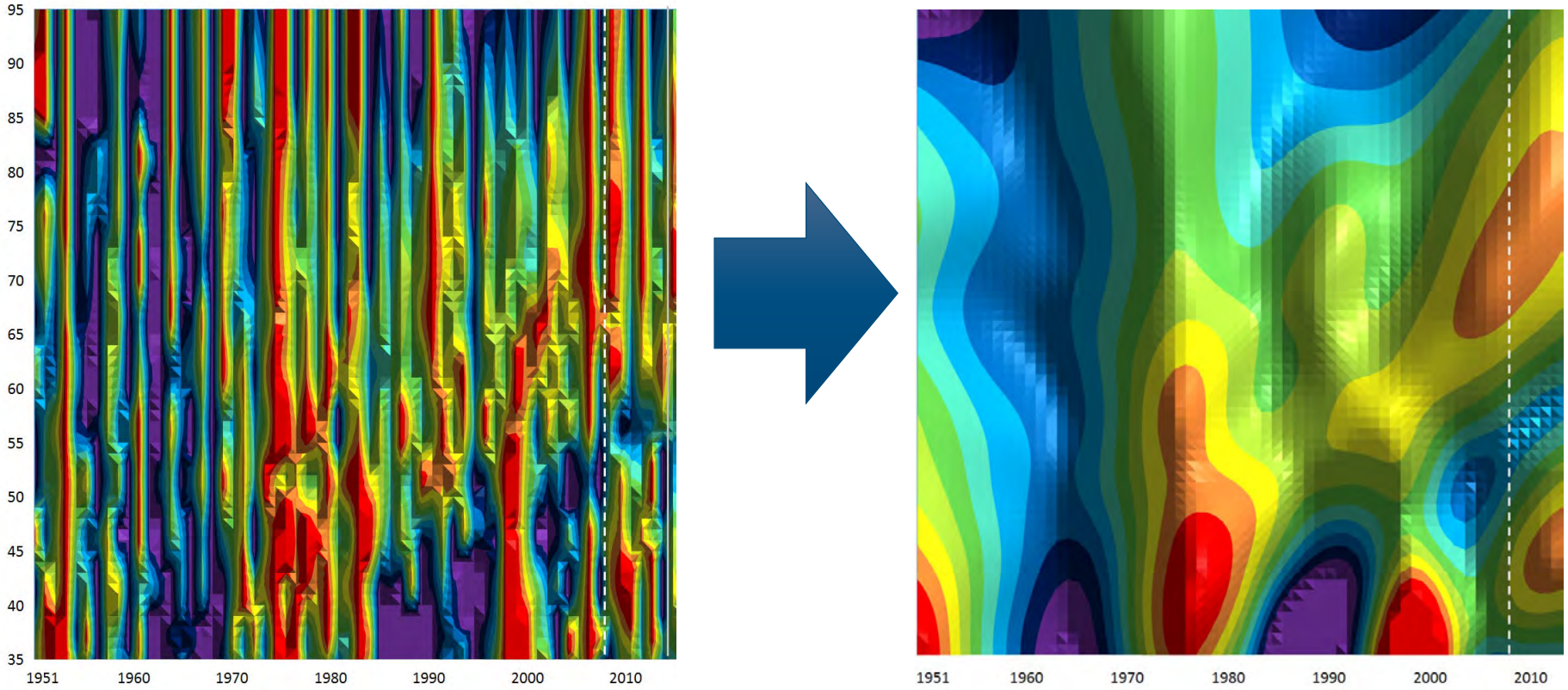
Ungraduated Historical Mortality Rates

Female Mortality Improvement



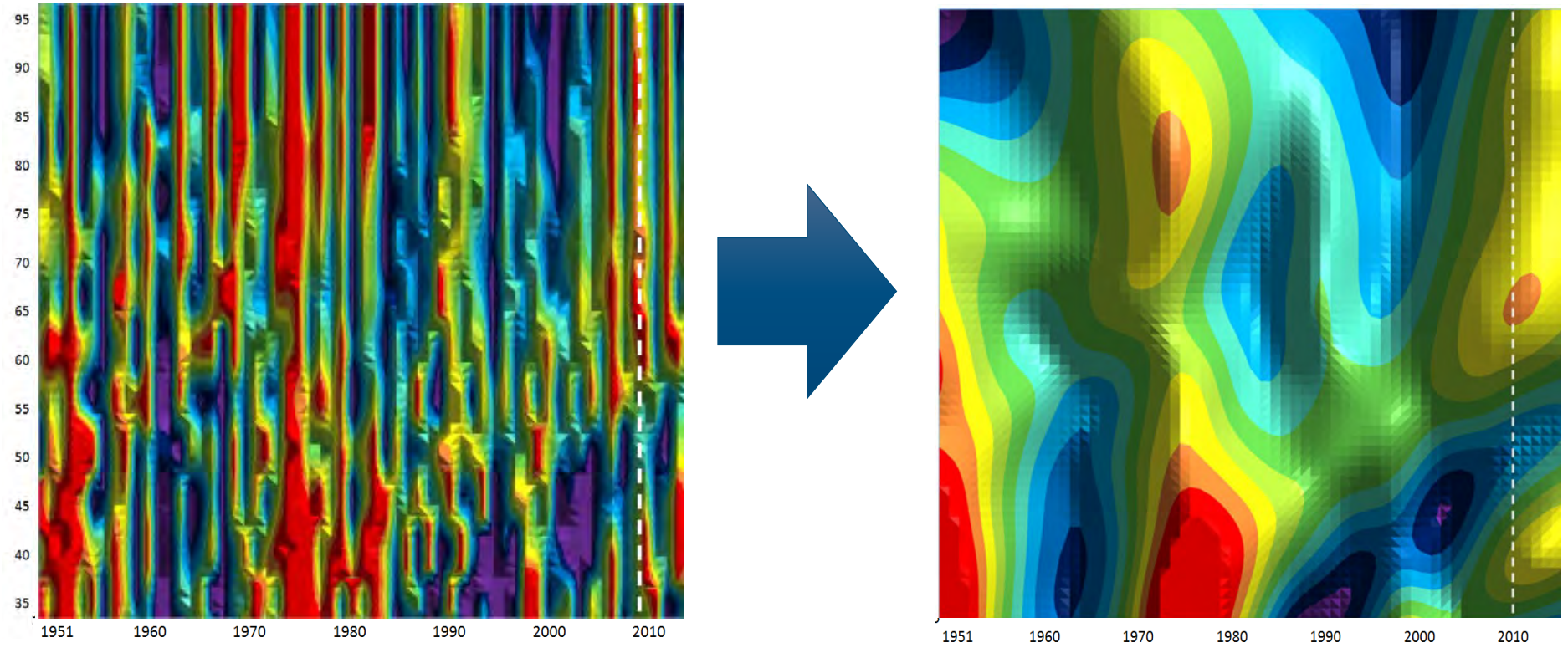
- Female improvement shows fewer ‘red’ peaks
- Cohort effects are visible in the ungraduated female data as well

Graduated SSA Experience (Male)



- Graduation allows the trends to emerge which show the period-effect ridges as well as more clearly defined cohort influences

Graduated SSA Experience (Female)



- Female experience shows similar diagonal cohort patterns

2019 ANNUAL MEETING & EXHIBIT

Development of Scale MP-2014

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Scale MP-2014 Background

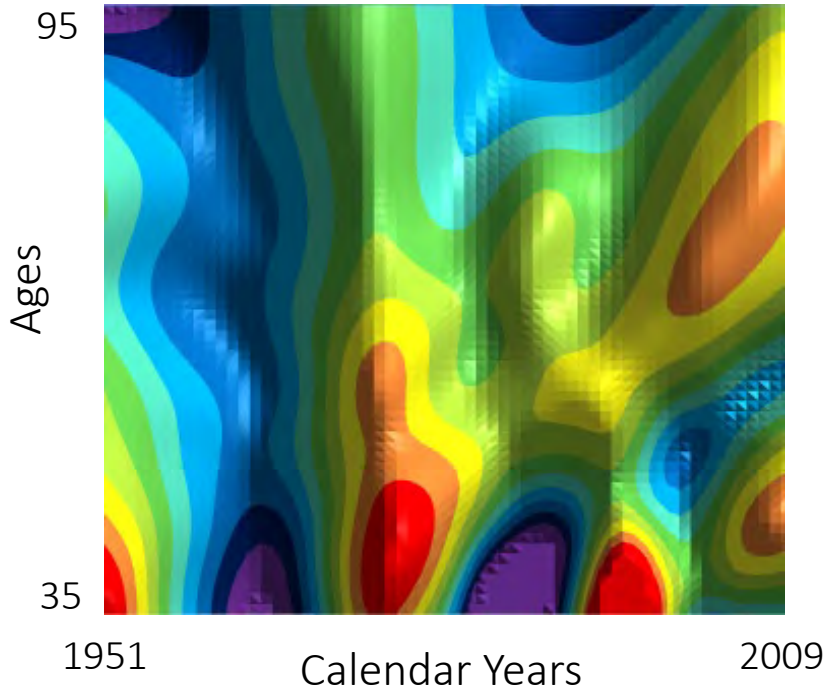
- Heat maps showed presence of cohort effects and period effects in U.S. historical data
- RPEC aimed to reflect these effects in future mortality improvement projection
- Decided to create a 2-dimensional scale actuaries could apply prospectively
- Key question: How to take historical mortality improvement data and extrapolate it into the future?
  - RPEC needed to develop a model

RPEC_2014 Model

- Two-dimensional rates based on same principles underpinning CMI (UK) model
  - Near-term rates should look like the recent past
  - Long-term rates should be based on “expert opinion”
  - Smooth transition between near- and long-term rates
- Historical mortality trends based on SSA population data through 2009
  - Graduated with 2D Whittaker-Henderson
  - Final model incorporates a two-year step-back (to 2007) to mitigate possible “edge effects”

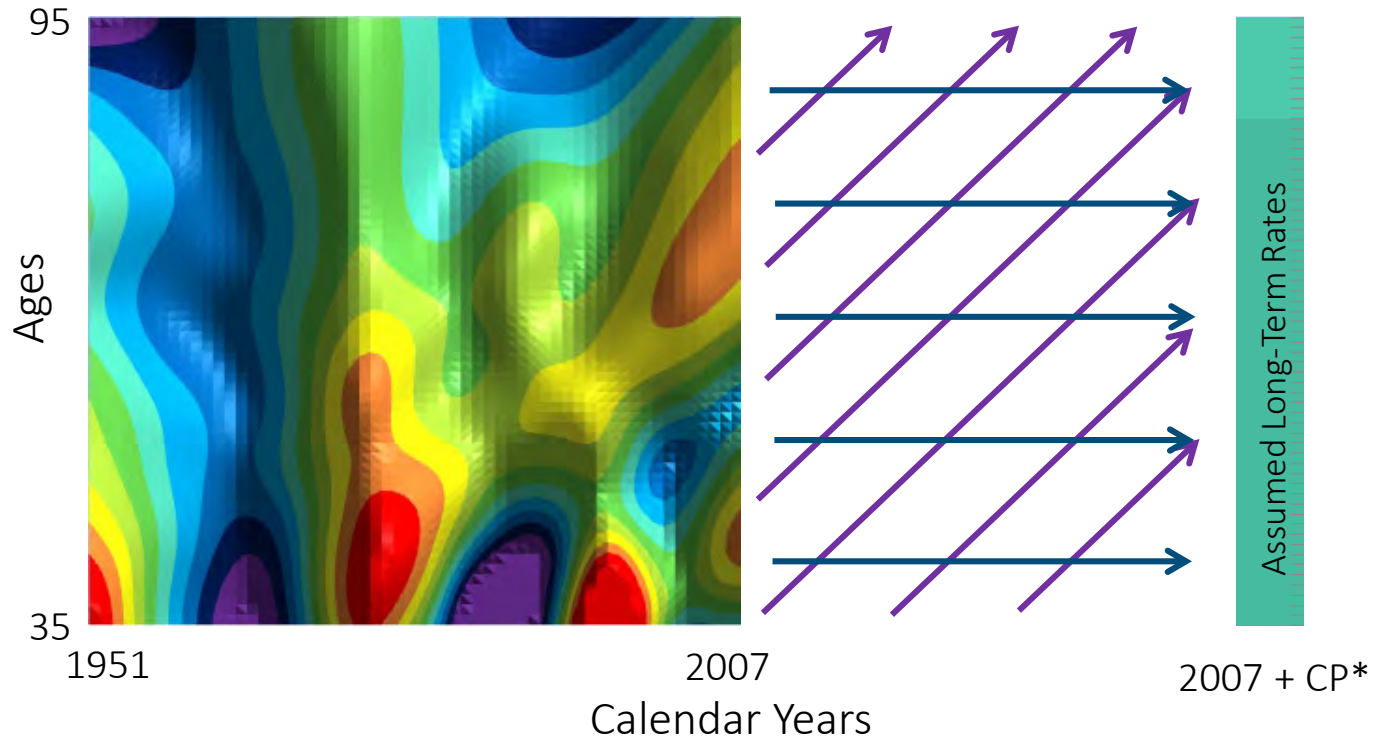
RPEC_2014 Model: Historical MI

- Original RPEC_2014 model was based on SSA mortality data through 2009



RPEC_2014 Model: Interpolation

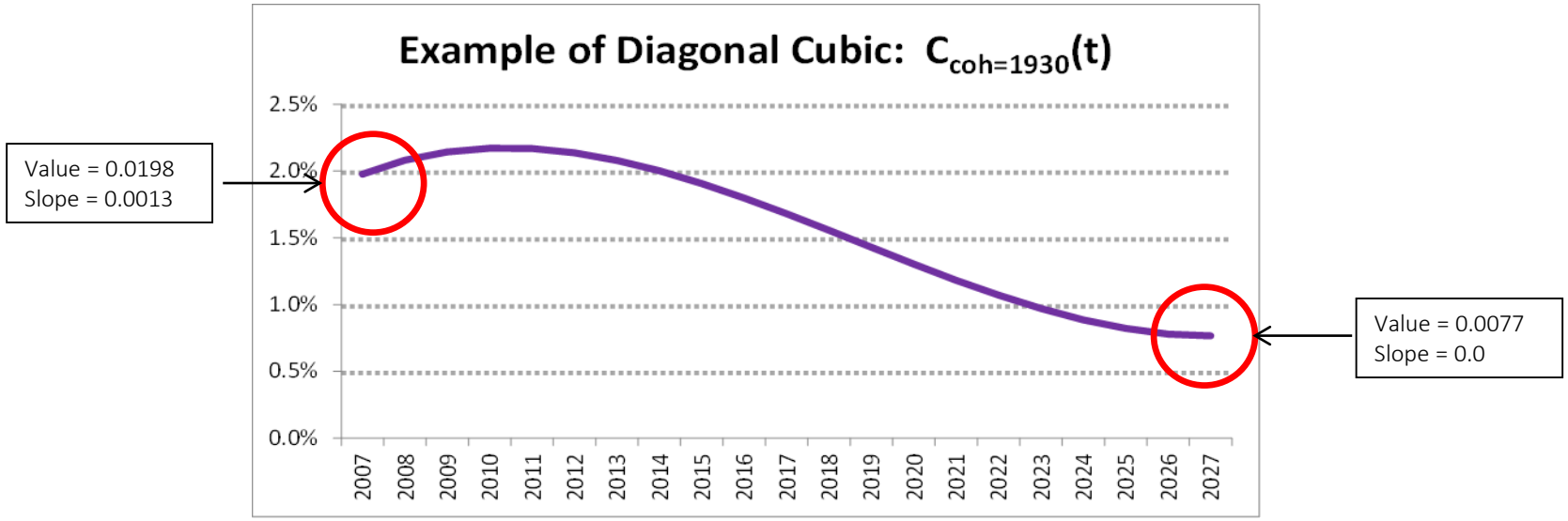
- Interpolation process began with MI rates in 2007



* CP = Convergence Period

RPEC_2014 Model: Interpolation

- For each gender/age combination, RPEC developed two cubic polynomials that satisfied four criteria

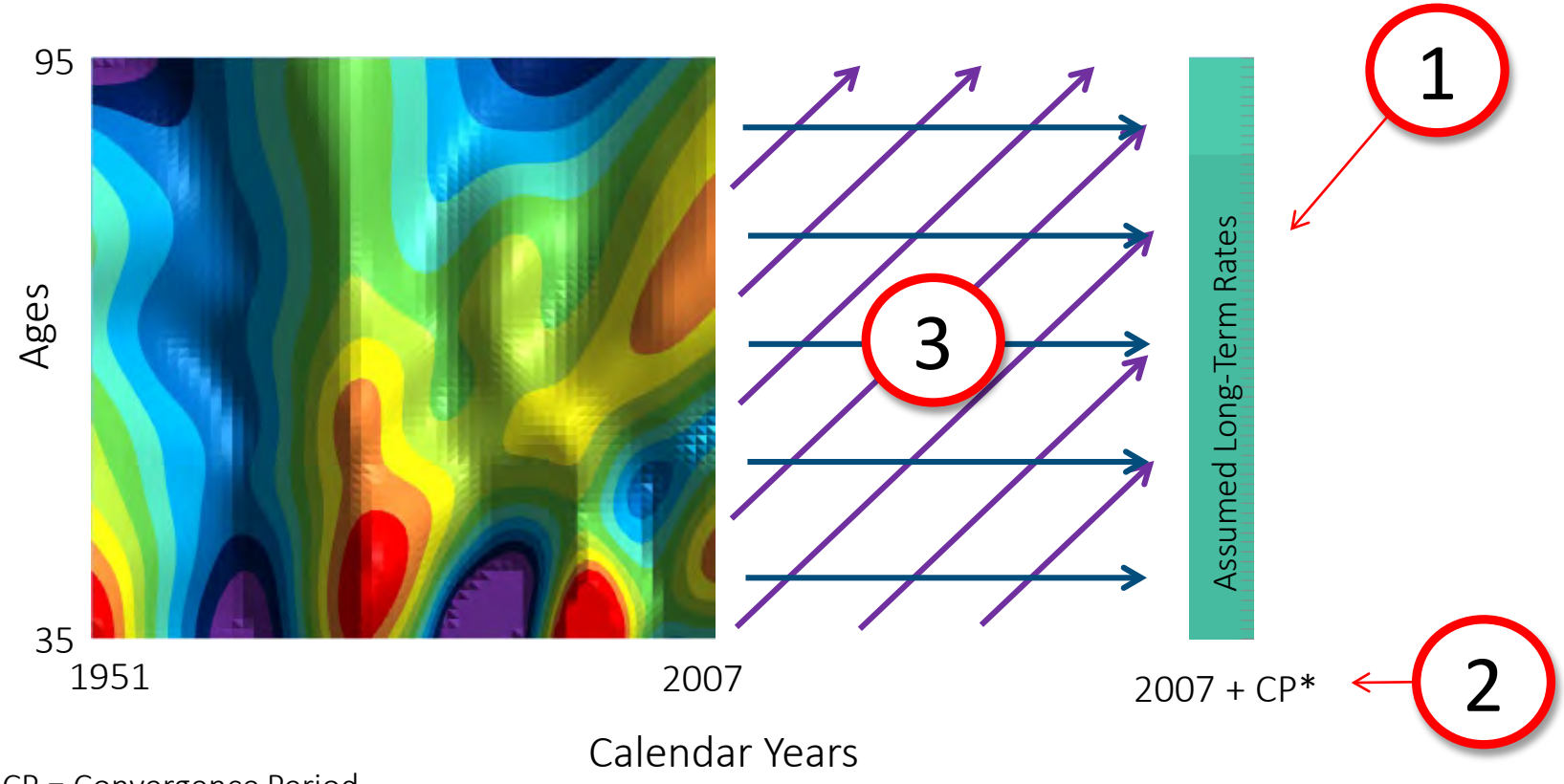


$$C_{coh=1930}(t) = 0.0198 + 0.0013\,(t\text{-}2007) - 0.00022075\,(t\text{-}2007)^2 + 0.00000628\,(t\text{-}2007)^3$$

RPEC_2014 Model: Interpolation

- Three key assumptions in RPEC_2014 model:
  1. Long-term rate of mortality improvement
  2. Length of convergence period
  3. Blending of age/period and cohort interpolations

RPEC_2014 Model: Interpolation

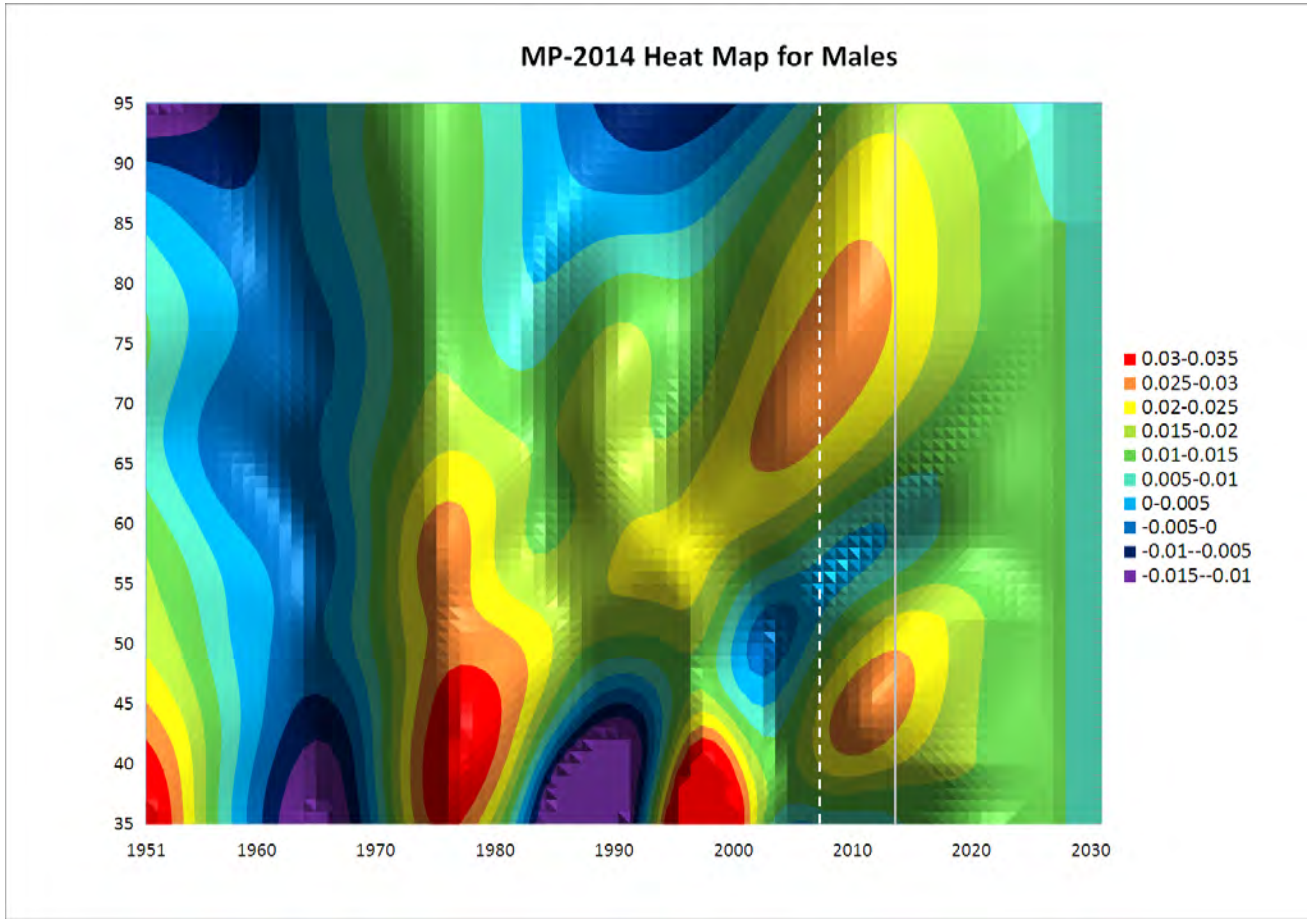


* CP = Convergence Period

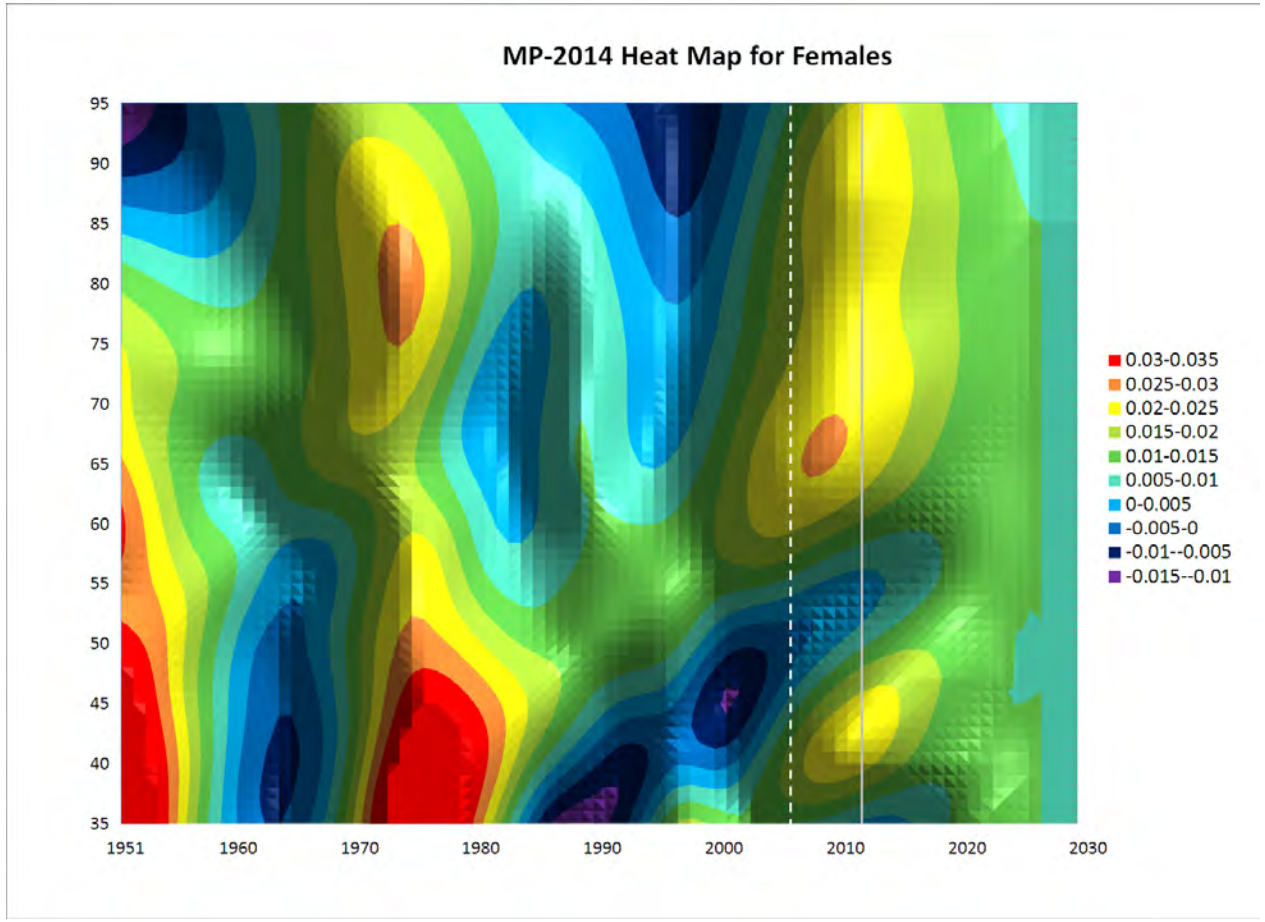
Scale MP-2014 Assumptions

- Scale MP-2014 is the output from the RPEC_2014 model when RPEC's selected assumptions are used.
- The "committee-selected" assumption set:
  - 1. Long-term rates:
    - Flat *1.0%* through age 85
    - Sight linear taper to *0.85%* at age 95
    - Then linear decrease to *0.0%* at age 115
  - 2. Convergence periods: *20 years* for both age/period and cohort effects
  - 3. Blending of age/period and cohort interpolations: *50%/50%*

Scale MP-2014: Heat Map for Males



Scale MP-2014: Heat Map for Females



2019 ANNUAL MEETING & EXHIBIT

Evolution of RPEC_2014 Model and "MP" Scales

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Emerging Data

- Scale MP-2014 based on data through 2009
- RPEC_2014 model uses recent mortality improvement as a starting point and “jumping-off” slope for projection
  - Most recent years of data are very important to model output
- Each October, RPEC has published annual updates to the RPEC_2014 model and Scale MP-2014 to reflect most recent available data
  - Scale MP-2019 and RPEC_2014_v2019 released October 2019

Model Improvements

- RPEC incorporated two new changes beginning with Scale MP-2016:
  - Set “jumping off” slope equal to zero
    - Each year, incorporating emerging data introduced high year-over-year volatility in pension liability calculations
    - Practitioners found these liability changes difficult to explain
    - Change prevents recent rising or falling mortality improvement from being extrapolated further into the future
  - Shortened age/period (“horizontal”) component of the convergence period from 20 years to 10 years
    - Analysis of historical U.S. mortality data suggests that “period effects” wear off more quickly than 20 years.

History of Changes in Annuity Factors

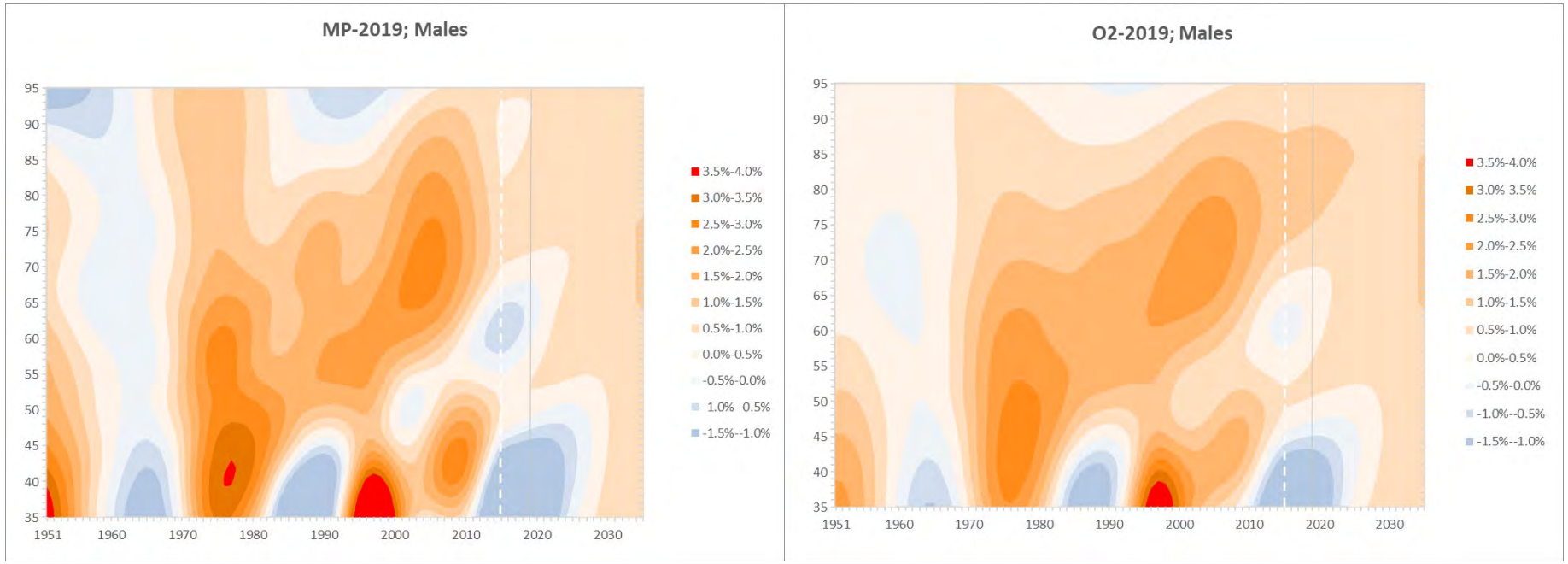
	Age	MP-2015	MP-2016	MP-2017	MP-2018	MP-2019
Females	25	-1.4%	-1.3%	-0.7%	-0.4%	-0.4%
	35	-1.4%	-1.4%	-0.7%	-0.4%	-0.3%
	45	-1.5%	-1.5%	-0.7%	-0.4%	-0.3%
	55	-1.5%	-1.5%	-0.7%	-0.3%	-0.3%
	65	-1.7%	-1.3%	-0.6%	-0.2%	-0.3%
	75	-3.0%	-1.8%	-1.0%	-0.3%	-0.5%
	85	-4.5%	-3.2%	-1.5%	-0.2%	-0.8%
Males	25	-0.9%	-1.7%	-0.9%	-0.7%	-0.6%
	35	-1.0%	-1.8%	-0.8%	-0.7%	-0.5%
	45	-1.1%	-1.7%	-0.8%	-0.6%	-0.4%
	55	-1.2%	-1.6%	-0.8%	-0.5%	-0.3%
	65	-1.4%	-1.5%	-0.7%	-0.4%	-0.2%
	75	-2.7%	-1.7%	-1.0%	-0.3%	-0.6%
	85	-3.4%	-2.9%	-1.4%	-0.3%	-1.0%

- As improvement has slowed, annuity factors have consistently declined
- MP-2015 and MP-2016 rates reflect multiple years of new data

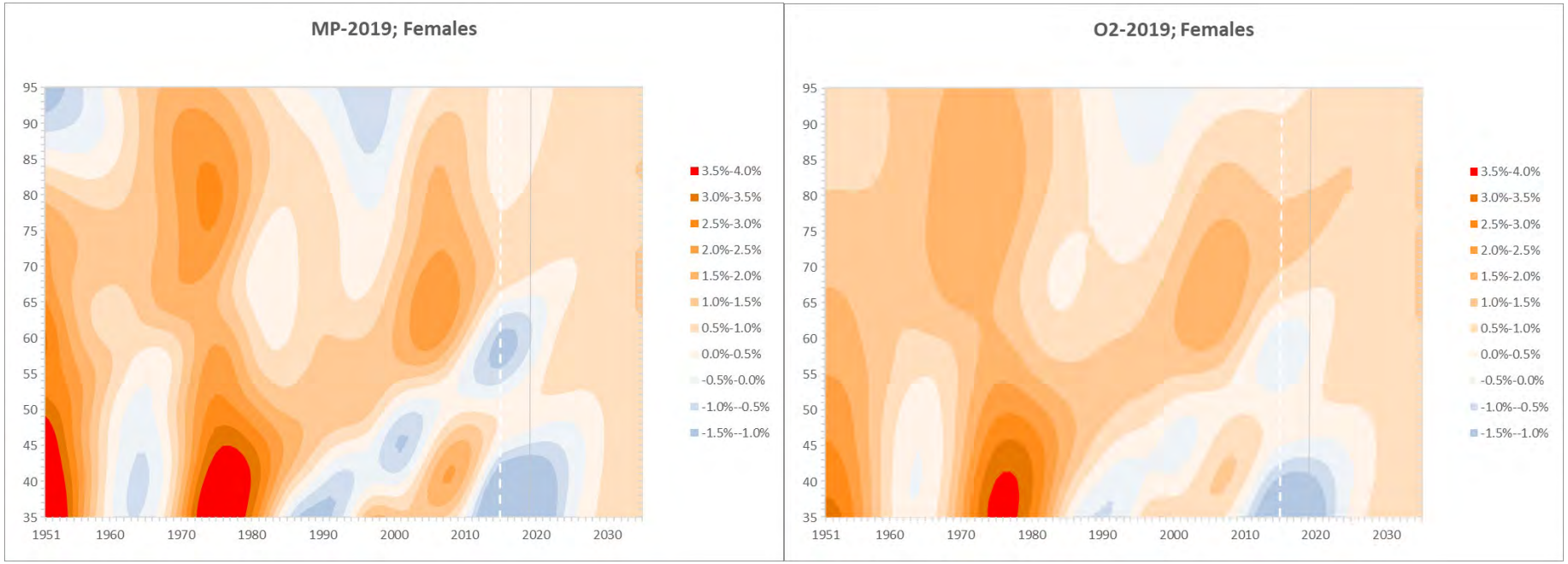
Alternative “Order-2” Model

- MP scales use “order-3” historical Whittaker-Henderson graduation
- Order-2 was also considered; compared to order-3 Whittaker-Henderson graduation, order-2 has:
  - Smoother historical two-dimensional rates
  - Smaller range of variation between lows and highs
  - Weaker historical fit
- In 2018, RPEC introduced the RPEC_O2 model in hopes that it might improve stability in pension liability calculations
  - Recent consistent trend in mortality improvement has muted potential stability advantages thus far.

Heat Map Comparison - Males



Heat Map Comparison - Females



Ongoing Mortality Improvement Research

- RPEC continues to review long-term rate of improvement against emerging data and studies
  - Social Security data indicates long-term improvement rates for 65-85 slightly above 1% annually over last 65 years
  - 2019 Social Security Technical Panel observed long-term improvement has been close to 1% in U.S.
    - Higher rates at younger ages and approximately 0.8% for ages over 65
  - RPEC assumption set begins linear taper down from 1% at age 85
    - Beginning age of taper is subject of discussion for future research
- SOA investigating application of RPEC_2014 model concepts to causes of death, socioeconomic subgroups