UNDERSTANDING MORTALITY

SUPPORTING LONGEVITY RISK TRANSFER THROUGH EDUCATION AND ANALYTICS

Longevity 9, Beijing

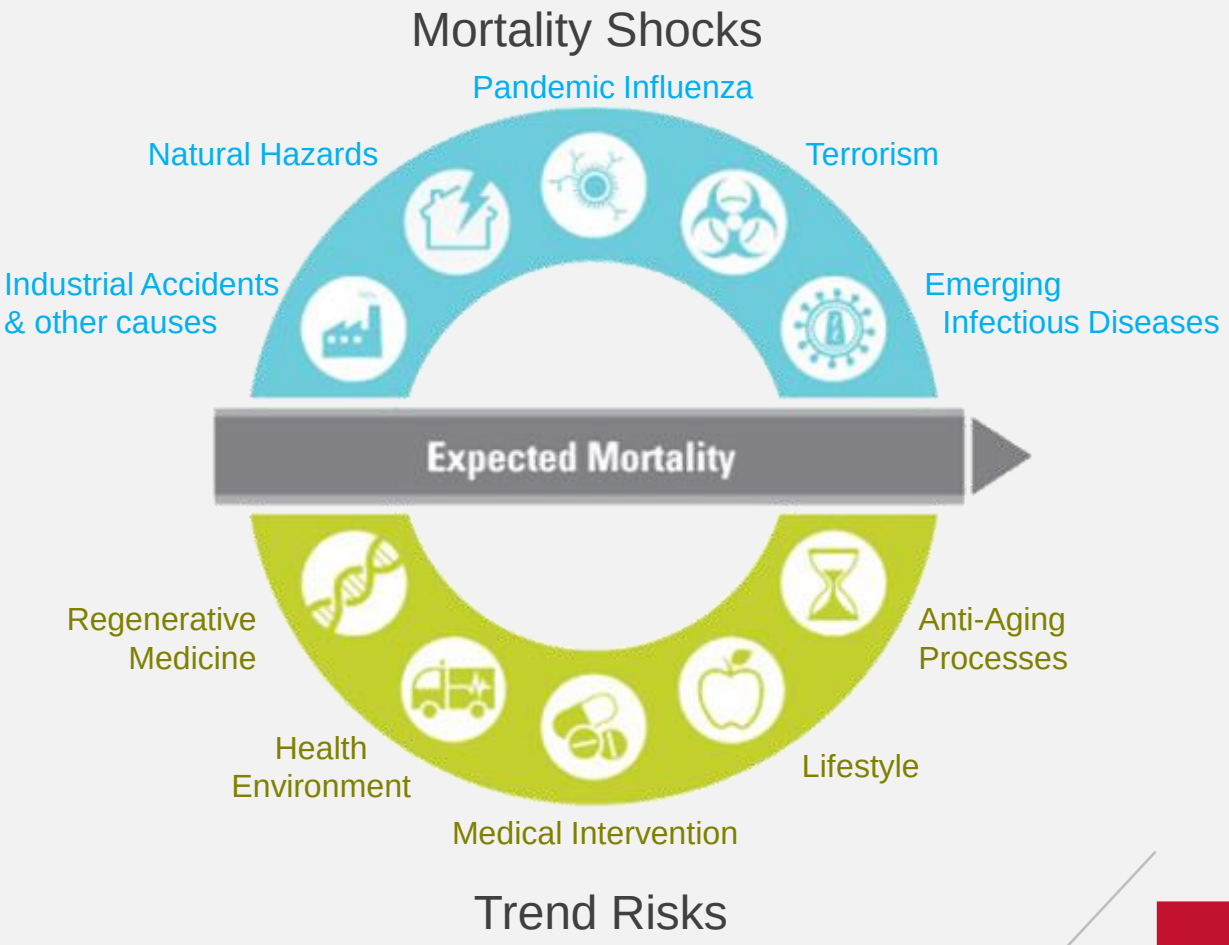
Dr. Andrew Coburn, Senior Vice President
Dr. Chris Hornsby, Model Development and Longevity Model Lead

RMS™

RMS BACKGROUND

- Best known for our catastrophe risk models
- Life insurance division since 2005
- Work with most major insurance and reinsurance companies in US & Europe
- $2 trillion worth of insurance and capital markets transactions based on RMS Risk Models
- Trusted by regulators and rating agencies for over 20 yrs
- RMS mortality and longevity models used for rated capital market transactions

RMS MORTALITY MODEL SUITE



RMS LIFERISKS

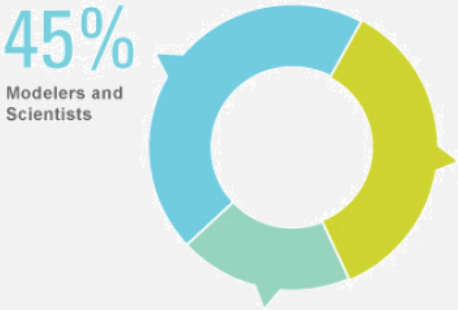
A specialized team to produce solutions for the life insurance industry

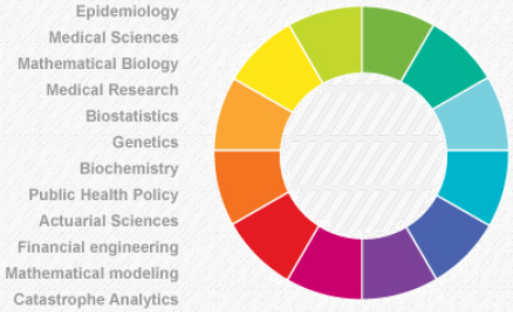
11
PhDs on the RMS LifeRisks technical team

40%
of RMS revenue reinvested in research and development

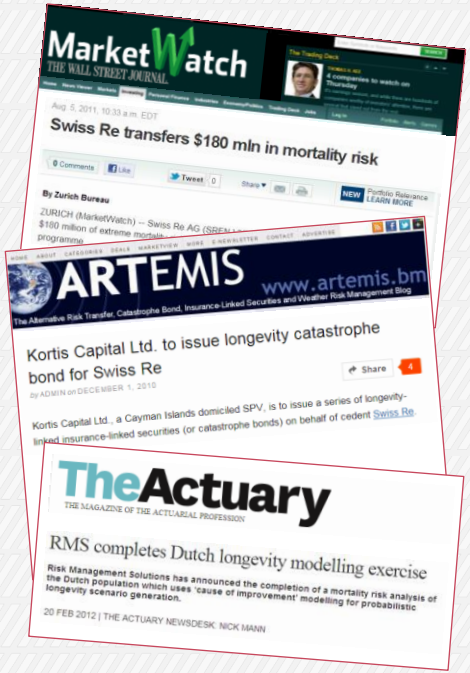
1
RMS catastrophist nominated as one of the 100 most influential people in finance
by Treasury and Risk Management Magazine 2004

350+
4 Books / 280 Papers / 70 Journal Articles
Risk publication output from the RMS LifeRisks technical team



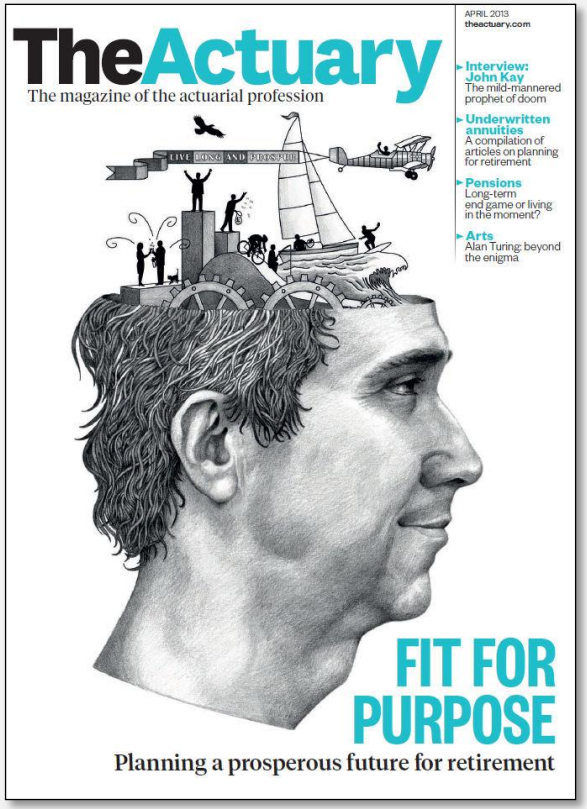


CAPITAL MARKETS TRANSACTIONS

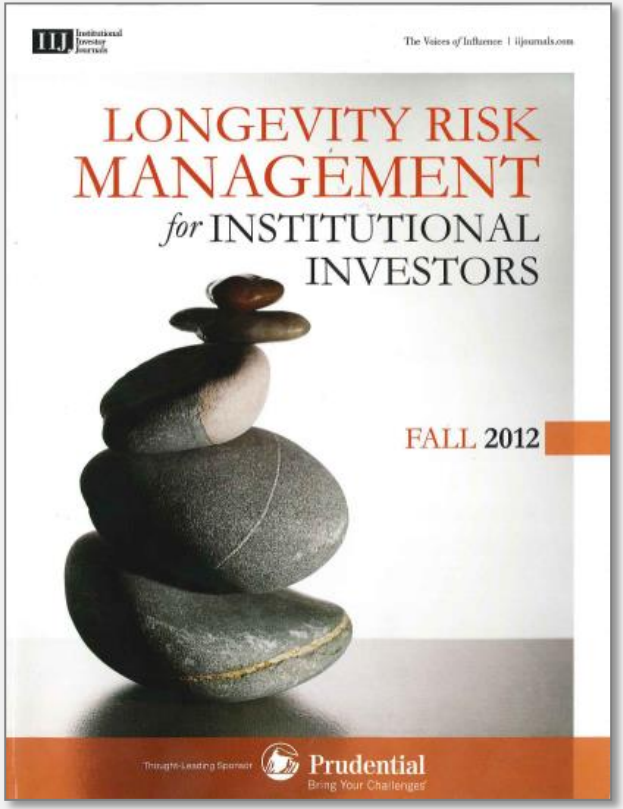


- Swiss Re VITA series
  - 2009, 2010, 2011, 2012
  - Excess Mortality bonds
  - RMS Excess Mortality models rated by Standard & Poor's
- Swiss Re KORTIS
  - Successfully closed and publicized Dec 2010
  - First ever successfully rated longevity bond
  - RMS Longevity Model rated by Standard & Poor's
- AEGON / Deutsche Bank longevity transaction
  - 'Record' size of a longevity transaction to the capital markets
  - Used Netherlands longevity modeling
  - Viewed as a "game changer" by other clients

THOUGHT LEADERSHIP



RMS article on psycho-social metrics for longevity risk featured on the cover of this month's special edition of **The Actuary** on underwritten annuities

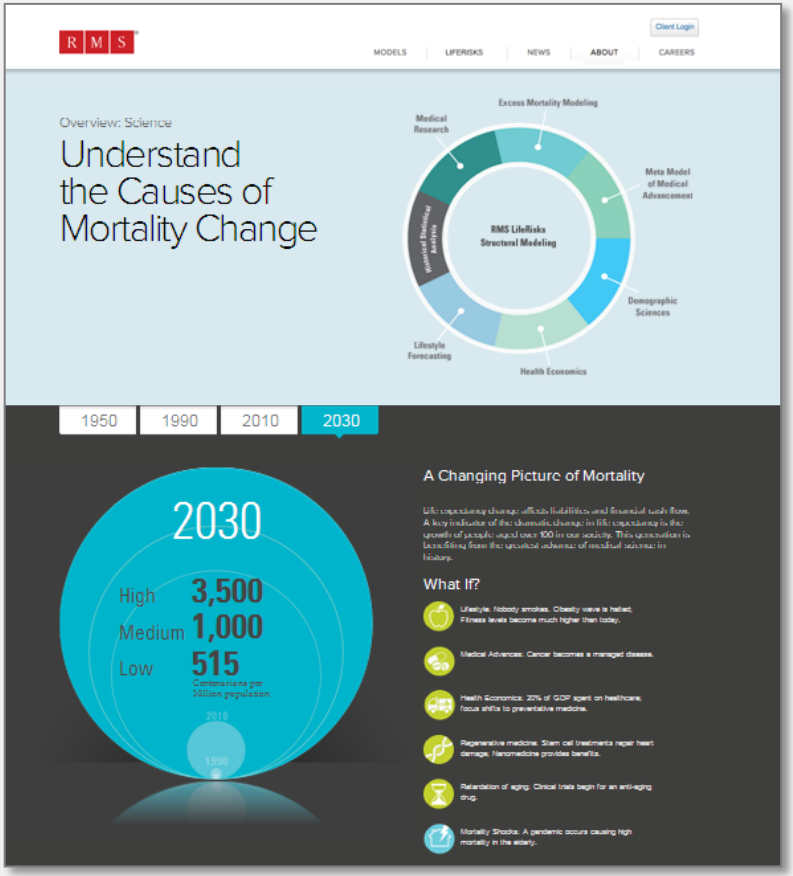


Longevity Risk Management: Fall 2012
RMS guest-edited edition of
Institutional Investor

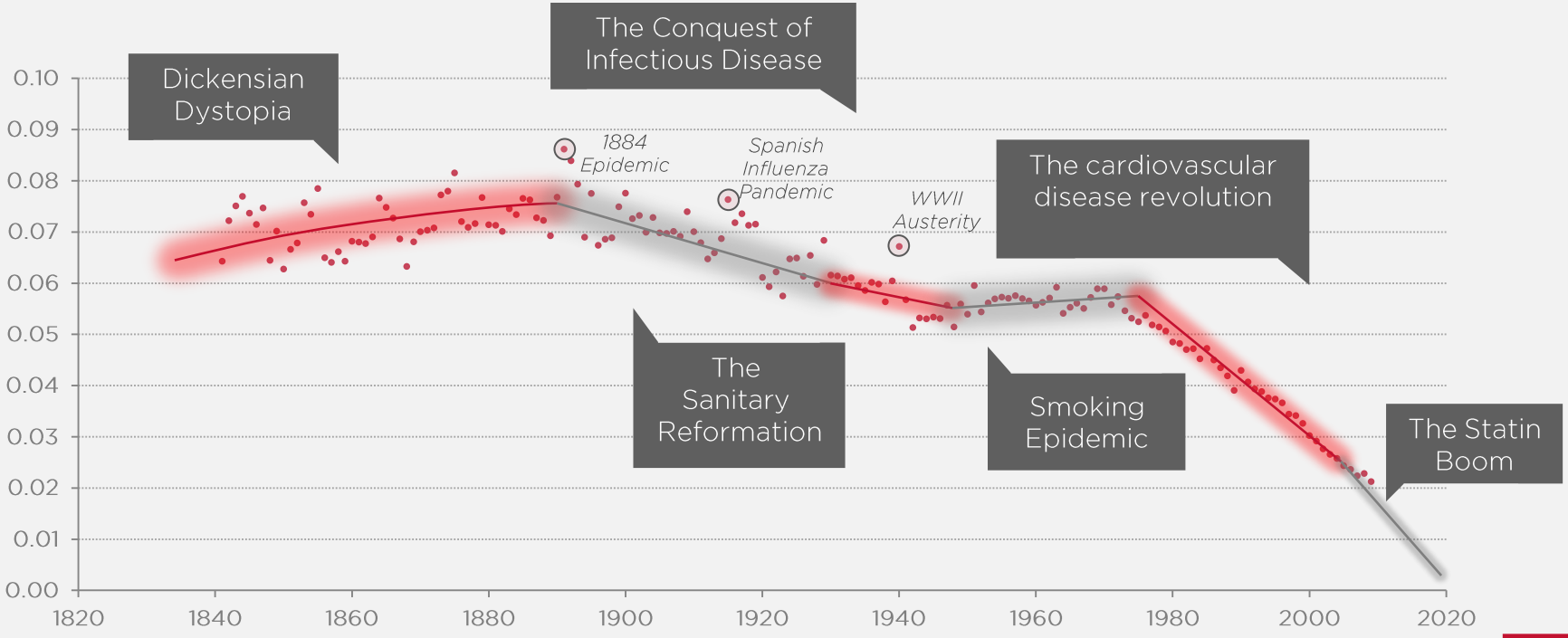
COMMITMENT TO SHARING KNOWLEDGE

RMS LifeRisks
Online resource center:
http://www.rms.com/liferisks

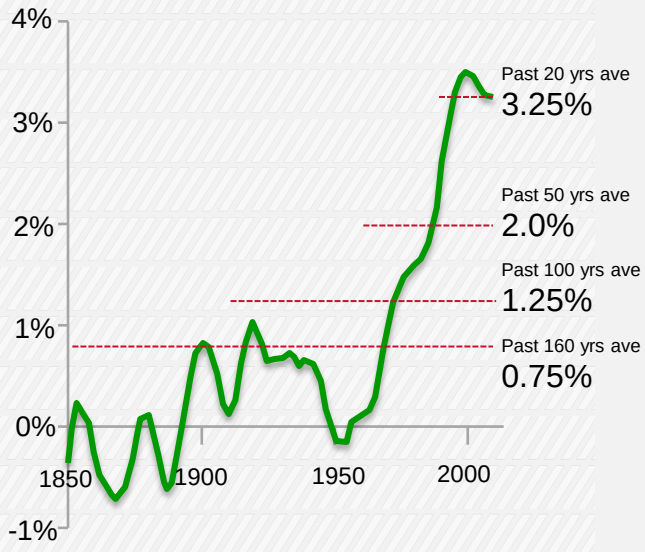
- Seminar presentations
- Whitepaper series
- Articles and commentary
- LifeRisks Monitor
- Collateral
- Client Alerts and Advisories
- Press releases



STRUCTURAL PHASES OF MORTALITY CHANGE



UNDERSTANDING CHANGING MORTALITY

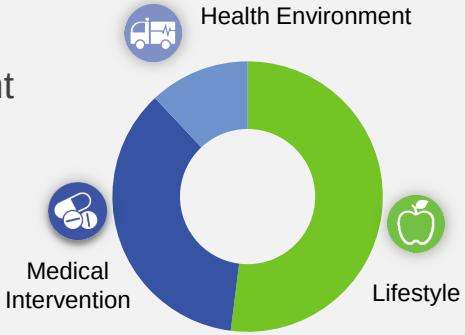


Mortality Improvements UK males
aged 65

A Century of Change and then…

40 Years of Unrelenting Improvement

- Detailed analysis of the causes of the recent phase of high improvement by epidemiologists and demographers
- Changing lifestyles
  - big influence from reduced smoking
- Medical intervention a significant cause
  - preventative drugs like antihypertensives and statins
  - Improved treatments for heart attacks
- Health environmental causes an additional minor contributor




American Heart Association. Circulation

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Clinical Investigation and Reports

Explaining the Decline in Coronary Heart Disease Mortality in England and Wales Between 1981 and 2000

Belgin Unal, MD, MPH; Julia Alison Critchley, DPhil; Simon Capewell, MD

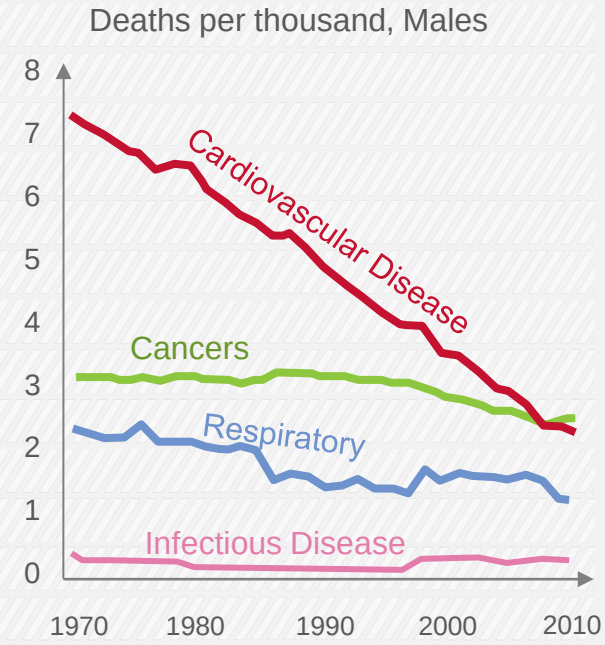
Author Affiliations

Correspondence to Dr Belgin Unal, Dokuz Eylul University School of Medicine Department of Public Health, Izmir, Turkey. E-mail belgina@liv.ac.uk

Abstract

Background— Coronary heart disease mortality rates have been decreasing in the United Kingdom since the 1970s. Our study aimed to examine how much of the

CAUSES OF DEATH



Improvements affect multiple causes of death

- Understanding how different causes of death are changing is a useful extra dimension of observation
  - The insurance industry should collect cause of death data from its policy-holders
- Causes of improvement operate across several causes of death
- Co-morbidity and interaction between medical conditions complicates the picture
- Structural models using ‘Cause of Improvement’ have proven more tractable than pure ‘Cause of Death’ models

VITAGIONS

Bioscience identifies a large number of causes that contribute to mortality change

Lifestyle

- Smoking
- Obesity
- Other lifestyle trends

Medical Intervention

Treatments for specific conditions:

- Cardiovascular Disease
- Cancer treatments
- Respiratory Disease
- Dementia
- Other key diseases

Health Environment

- Healthcare provision
- Sanitation, housing, environmental factors

Regenerative Medicine

New classes of treatment for repairing damaged systems e.g.

- Stem cell therapy
- Nanomedicine
- Individualized gene therapy
- Improvements in transplantation

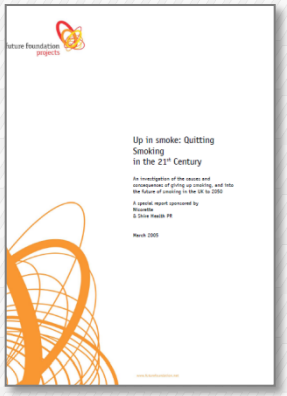
Anti-Aging Processes

Treatments to extend life through slowing natural processes of aging, e.g:

- Telomere Shortening
- IGF1
- Caloric restriction

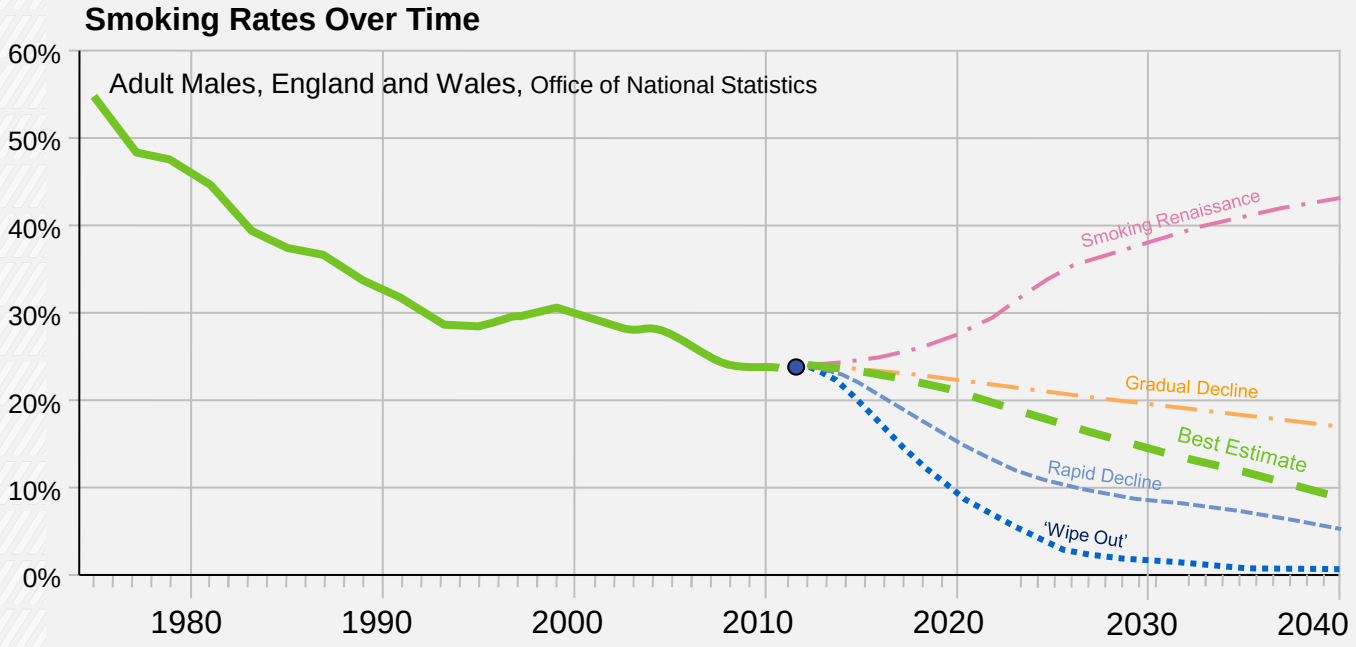
RMS™

SMOKING



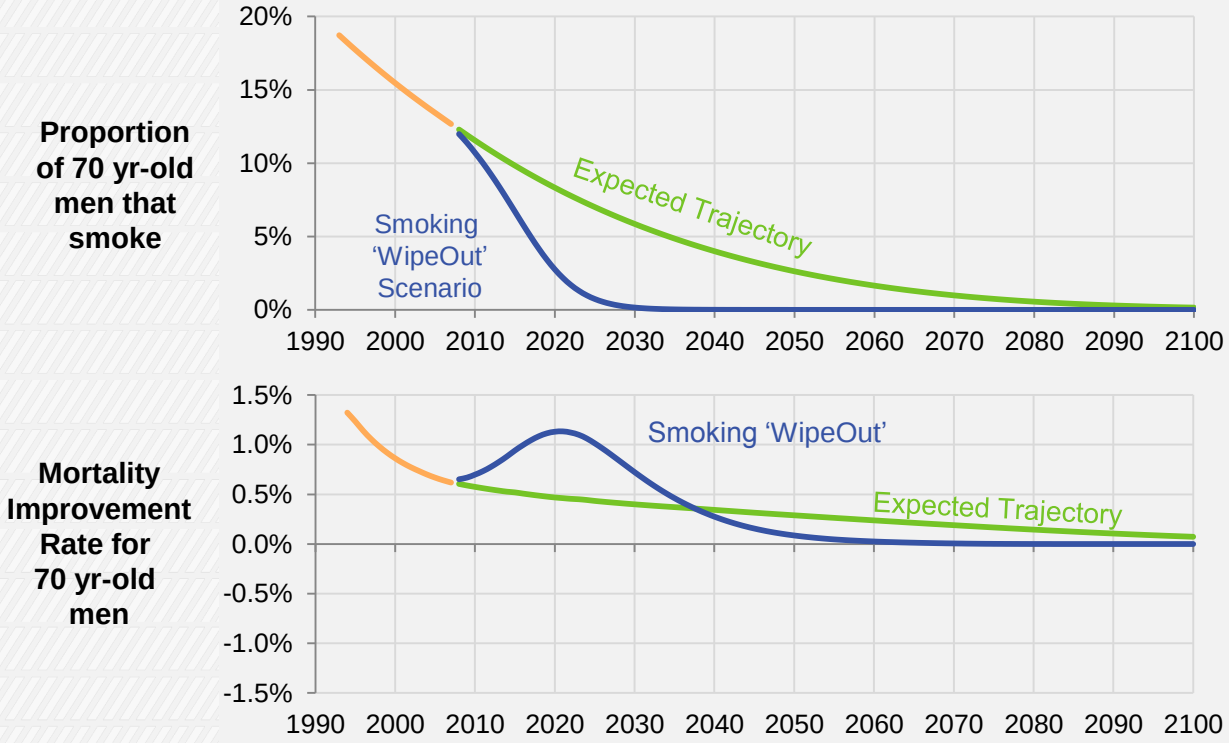
Future Foundation Projects
Up in smoke: Quitting Smoking in the 21st Century
Nicorette & Shire Health PR
March 2005

Projecting Future Smoking Rates

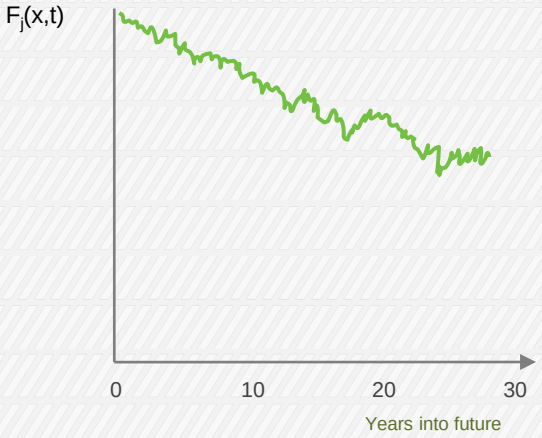


SMOKING

Impact of Smoking Reduction on Mortality Improvement



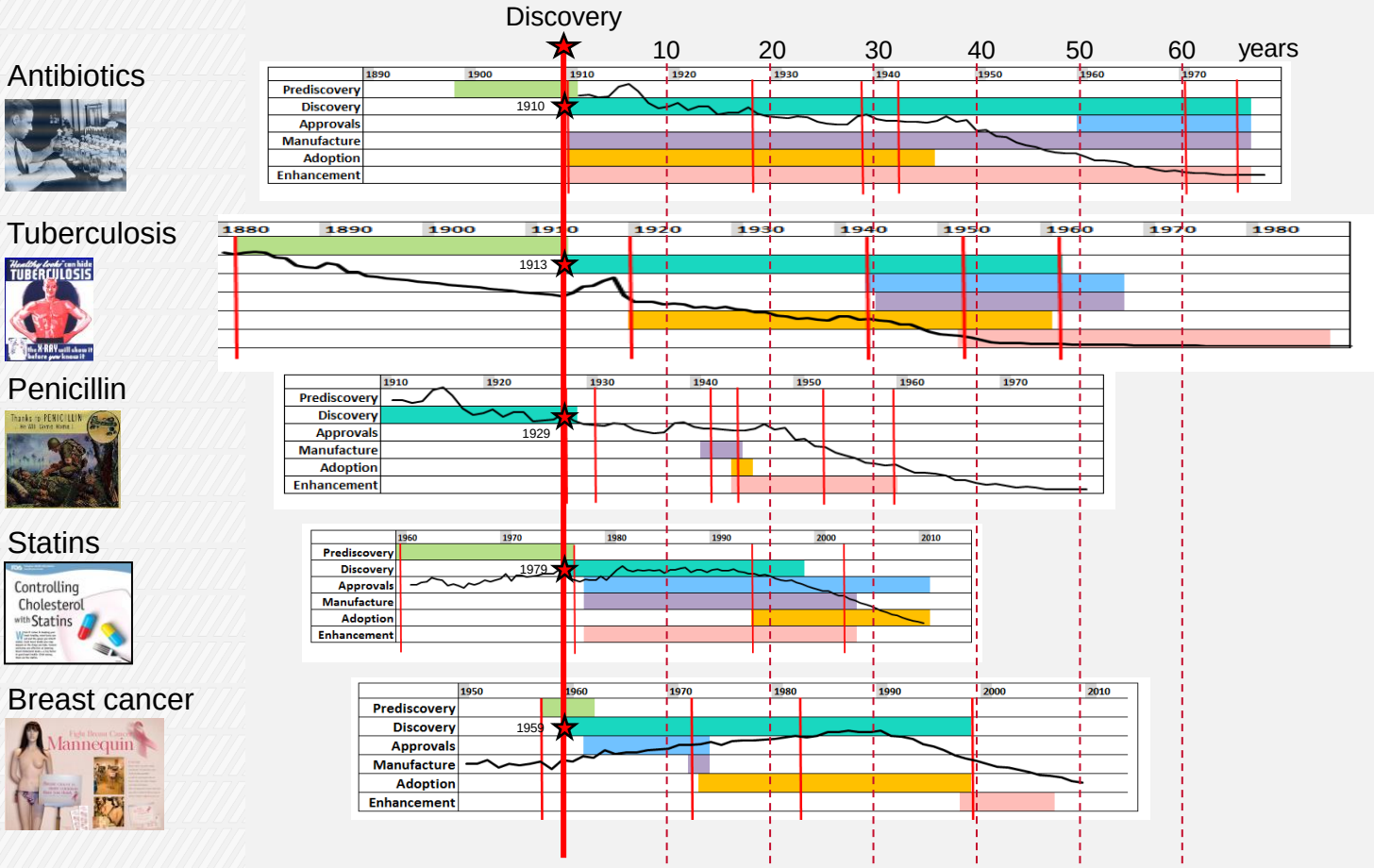
MODELLING MEDICAL PROGRESS



Medical breakthroughs and advances are sporadic

- Observations of the process of medical advance shows that it is serendipitous and subject to significant randomness
- Medical progress is punctuated by reversals and setbacks – for example discovering that a treatment causes side-effects
- It has long been observed that mortality improvement has the characteristics of a random-walk
- Structural modelling of cause of improvement is the first model to explain WHY
- An important contribution of bioscience is the parameterization of this ‘meta-model of medical progress’

Historical timelines for new medical innovations to impact mortality



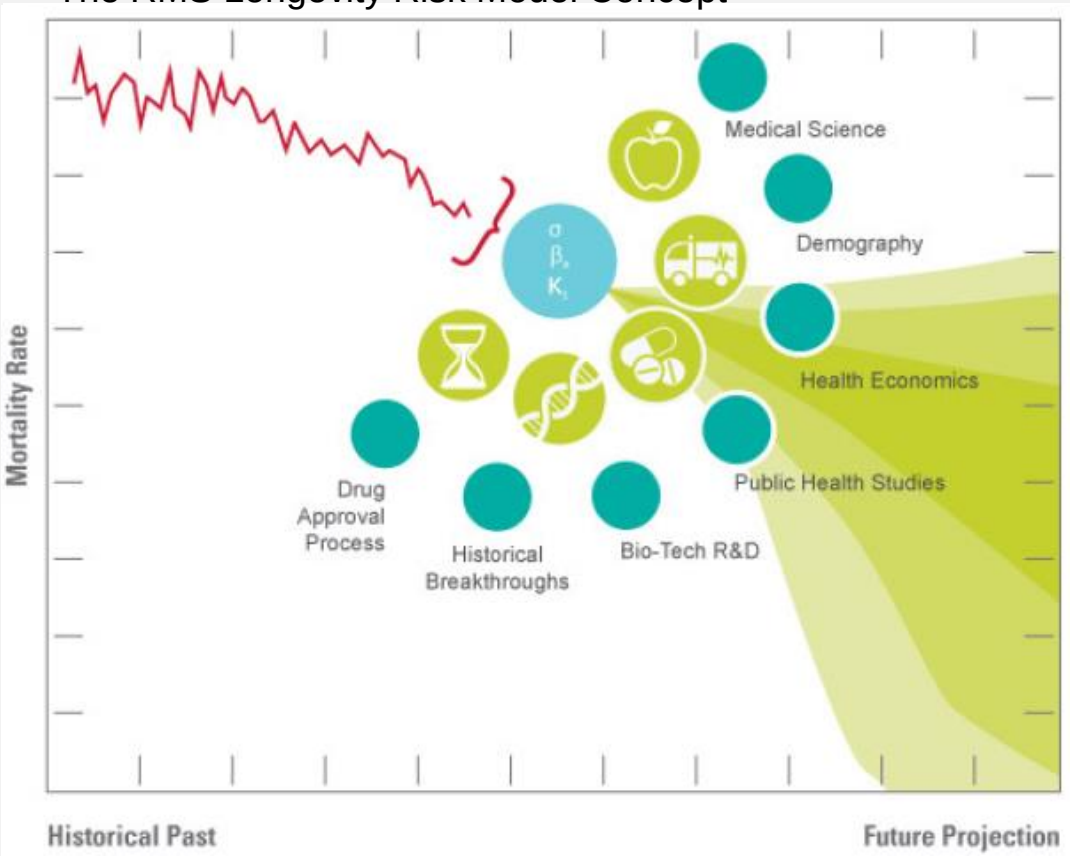
COMPLEMENTING ACTUARIAL SCIENCE

Standard Lee-Carter Model
Statistical projections of past experience are proven and powerful tools of actuarial expertise, but extrapolating past volatility can project medically implausible futures.

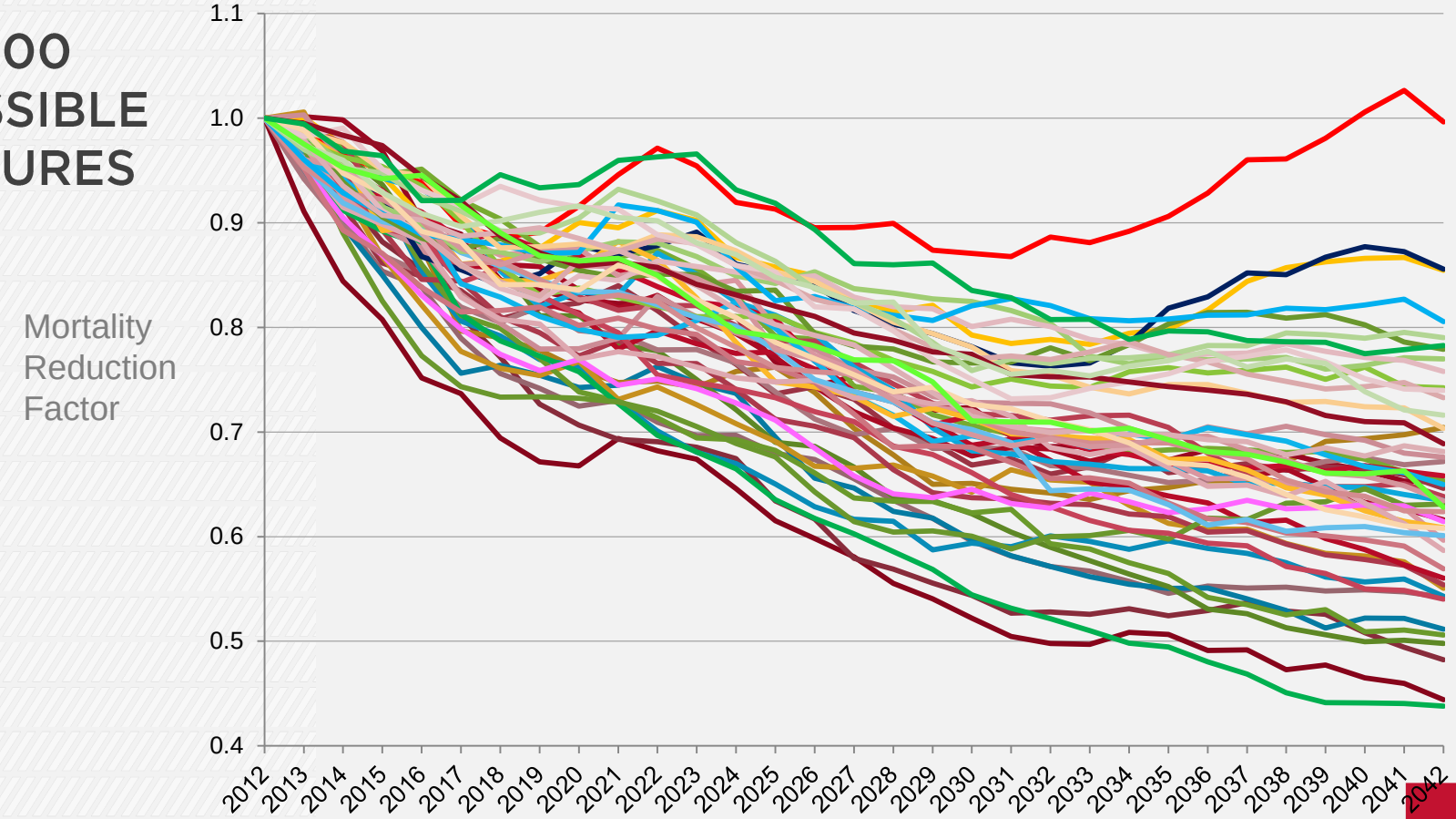
Overlaying a Vitagion Structure
Enhanced statistical projection by adding future projections by causes of improvement, provides realistic medical constraints on what could happen in future.

Multidisciplinary Scientific Research
Parameterization of vitagion models is informed by a detailed research program of best-of-class data, and sub-models of medical outcomes.

The RMS Longevity Risk Model Concept

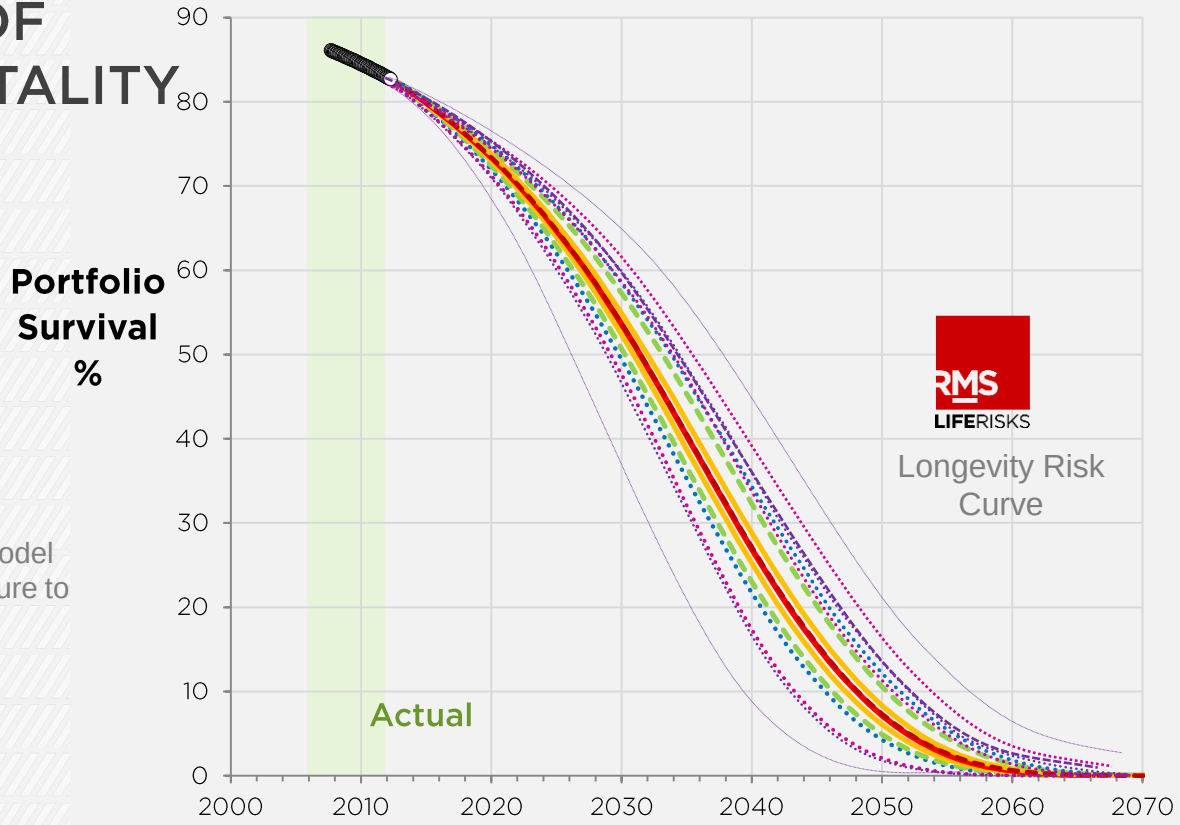


10,000 POSSIBLE FUTURES



THE PROBABILISTIC STRUCTURE OF FUTURE MORTALITY

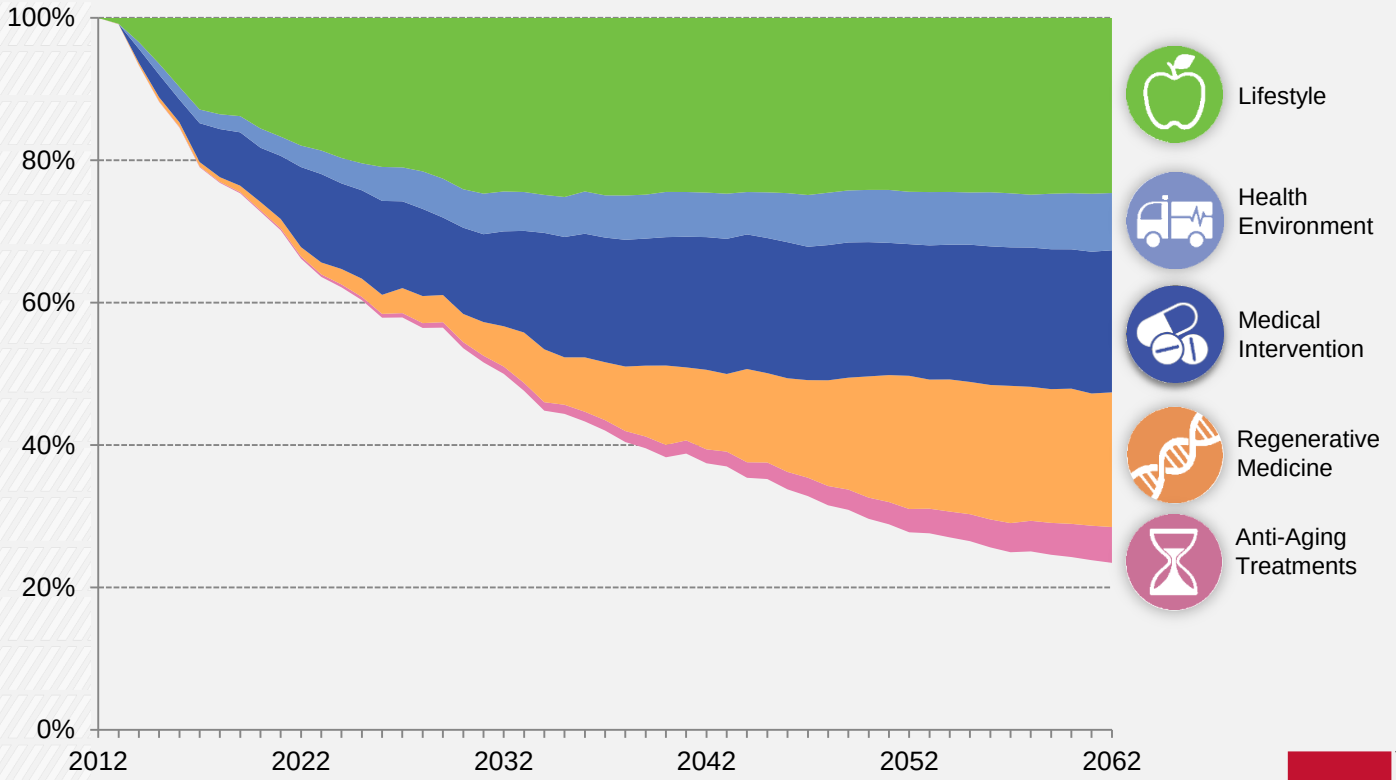
Characterizing the nature of lifestyle change and medical progress in a full stochastic model enables the uncertainty structure to be quantified



UNDERSTANDING SCENARIOS

- Fast increase in healthier lifestyle
- Smoking becomes de-normalized;
- Obesity trends slow dramatically

- Rapid Progress in Medical Intervention
- Cancer management improves dramatically.
- New monoclonal antibody drugs are effective and cheap.
- Continued rapid reduction of premature deaths from cardiovascular disease



ONLY ONE FUTURE WILL ACTUALLY OCCUR

What signals will indicate which path will emerge?

RMS LIFERISKS

LIFERISKS MONITOR

MARCH 2013

CONTENTS

- Finally stubbing out smoking
- Obesity rates drop in U.S. children
- $4 Billion boost for brain research
- Aging reversed in mice using stem cells and a "Longevity Gene"
- Other news in brief
- Book reviews
- Risk Management Solutions for the life & health insurance industry

This edition highlights what it will take to kick start a further decline in smoking rates, how some experts believe childhood obesity levels are flattening out, the huge increase in funding for brain research, and how researchers are targeting genes to target age-related diseases.

"A big driver of mortality improvement in the U.S. and Western Europe over the past few decades has been the dramatic decline in smoking rates. But in recent years the rate of decline has stalled. What would it take to restart the decline and to finally extinguish smoking as a habit in the population?

FINALLY STUBBING OUT SMOKING

In 2010, the U.S. Centers for Disease Control and Prevention set a series of ambitious targets for improving population health. The "Healthy People 2020" initiative set a target to reduce smoking prevalence in adults from 18% in 2011 to 12%. At current rates of reduction of about 4% per decade, this would not happen until nearly 2030. Why has the decline in smoking rates appeared to stall and what will it take to kick start further decline?

A variety of factors affect total adult prevalence of smoking, including rates of initiation of smoking in young people, quit rates, differential mortality rates in the elderly, and shifting population age demographics.

1

The RMS LifeRisks Monitor is dedicated to keeping clients abreast of bioscience developments

- As we progress through time, the uncertainty around future years' mortalities will reduce
- Certain events will make particular paths more likely
- Watch out for 'Sentinel' events that signal changes in the mortality regime
  - The end of the obesity epidemic
  - Smoking de-normalization
  - FDA approval of low-cost stem cell treatments
  - Radical change of the NHS
  - Low-cost drugs for reducing cancer mortality

Anatomy of a Successful Transaction
Modeling Firm Perspective

Anatomy Of A Successful Transaction

Payment Schedule

Sponsor

one-time **variable payment**

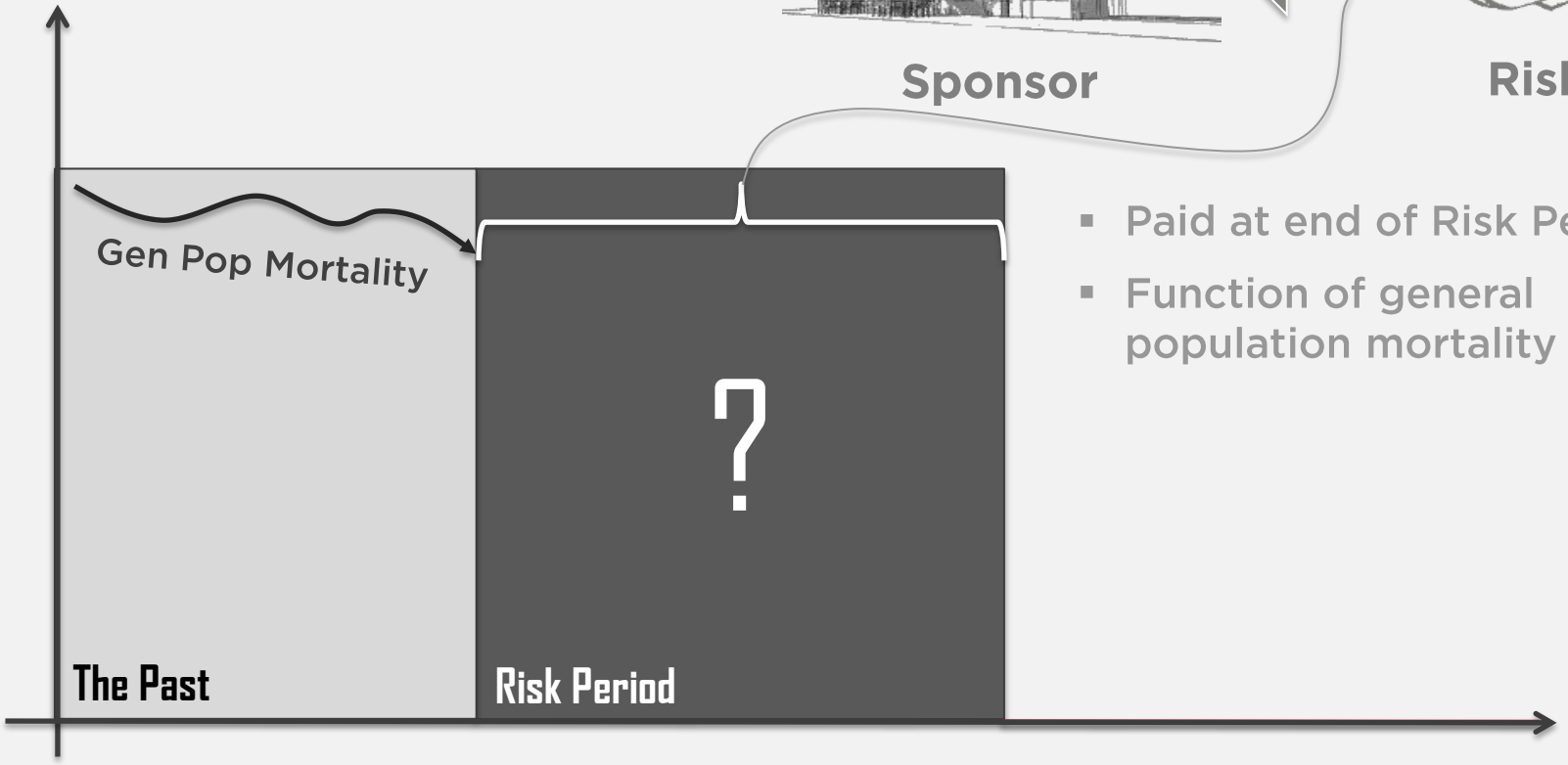
regular fixed payment

Risk Taker

Variable Payment

Sponsor

Risk Taker



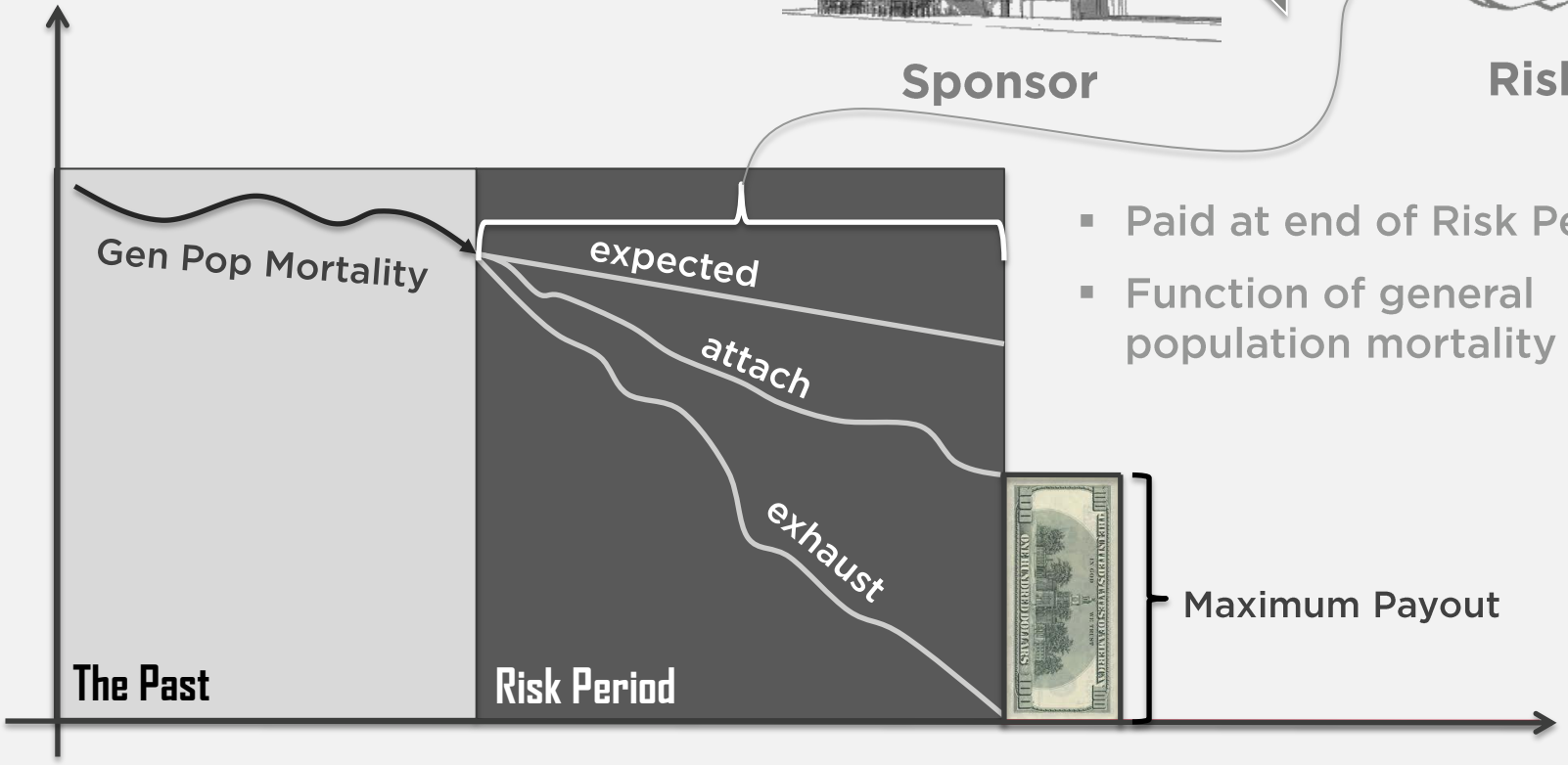
- Paid at end of Risk Period
- Function of general population mortality

Variable Payment

Sponsor

Risk Taker

- Paid at end of Risk Period
- Function of general population mortality

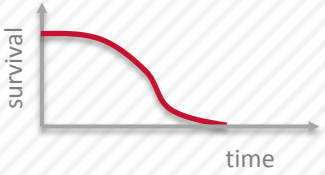


Variable Payment Function

General Population Mortality Rates

1

Cash-Flow Index: replicates insurance cash-flows



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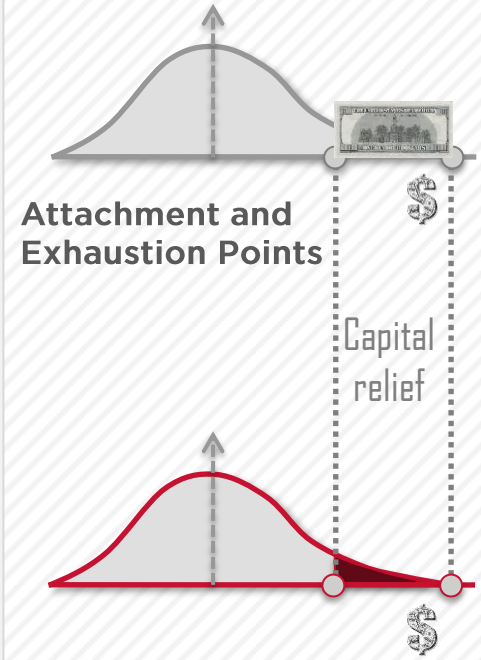
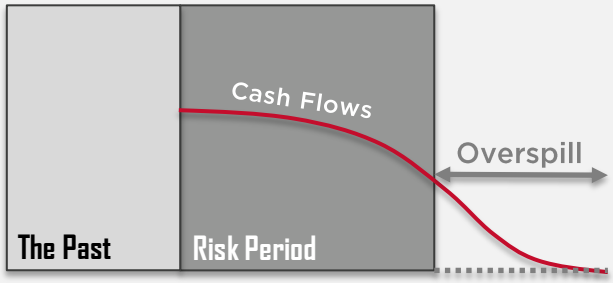


3

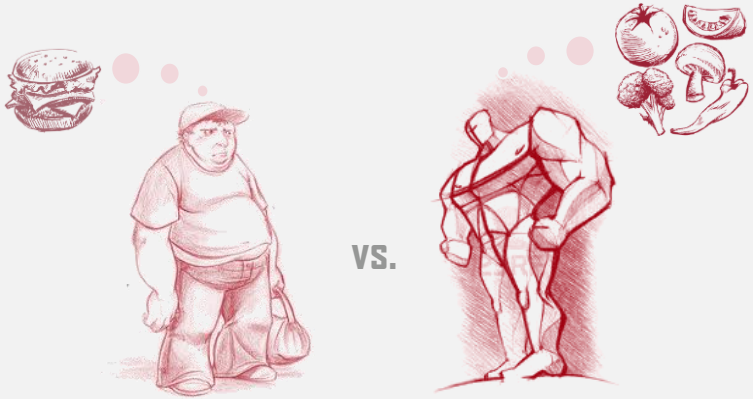
Cash Flow Index

Design Challenges



Duration Mismatch

How to hedge multi-decade risk with a 10-20 year instrument?

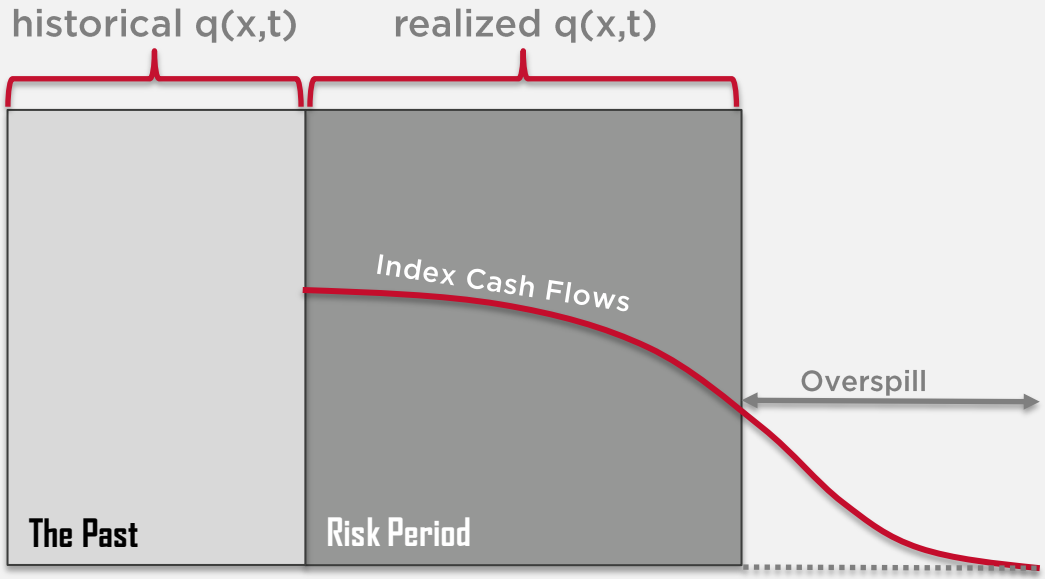


General vs. Insured Population

Capturing sponsor portfolio demographics

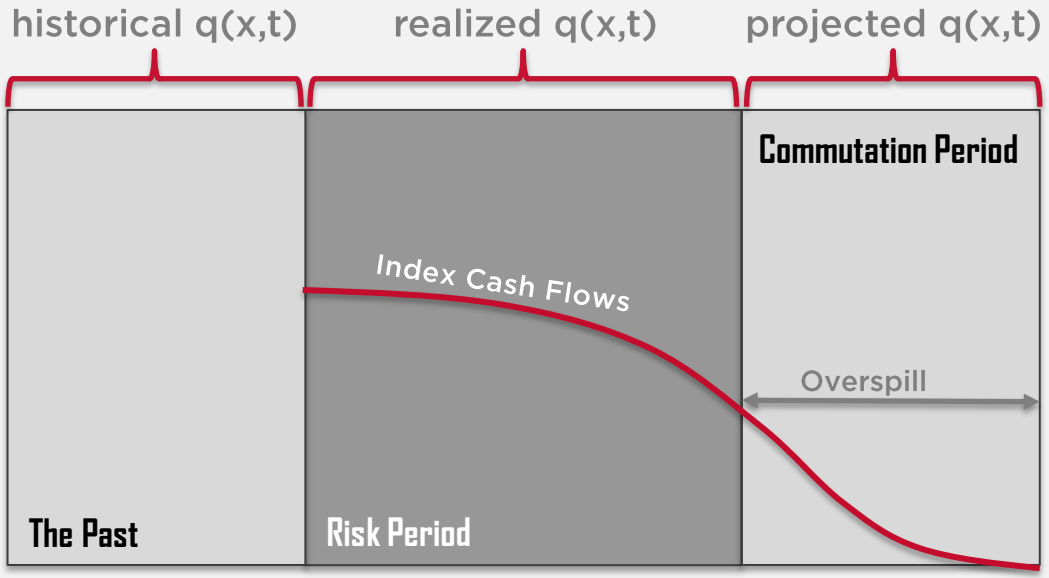
Cash Flow Index

Bridging the Duration Gap

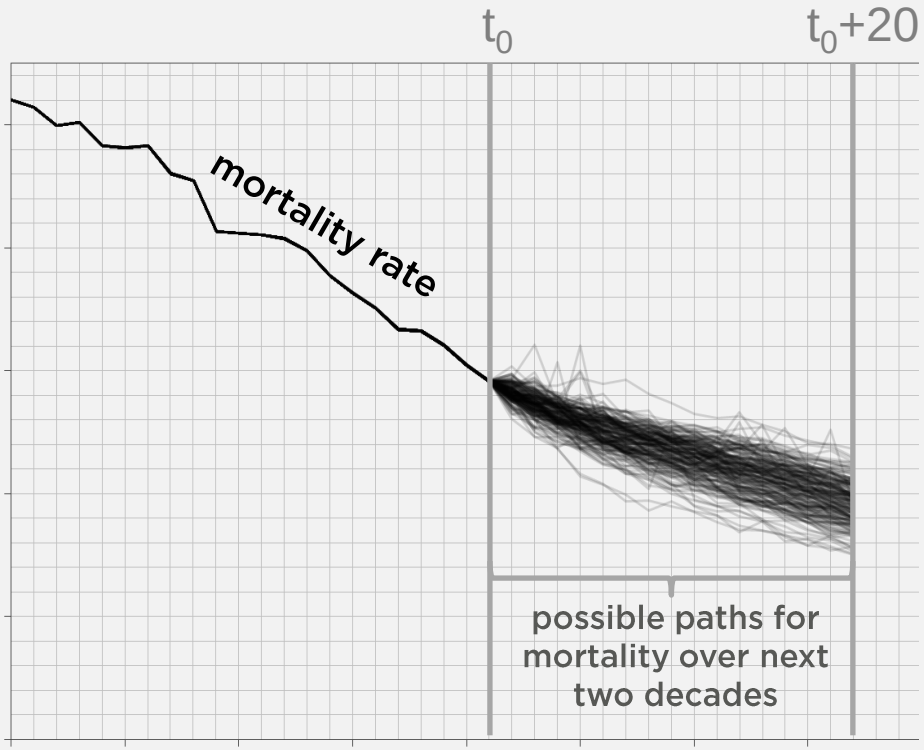


Cash Flow Index

Bridging the Duration Gap



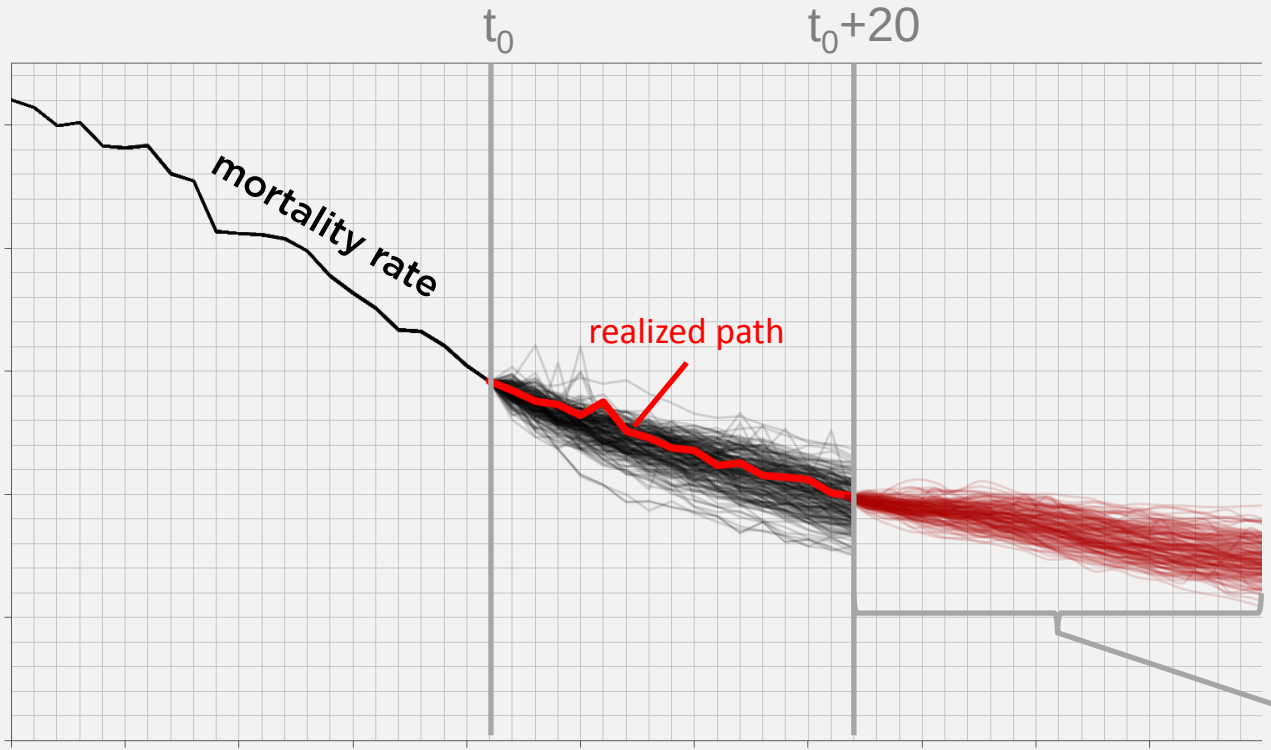
Simulating Risk Period Mortality



Mortality paths up to t_0+20 simulated using:

- Longevity model +
- Infectious disease model

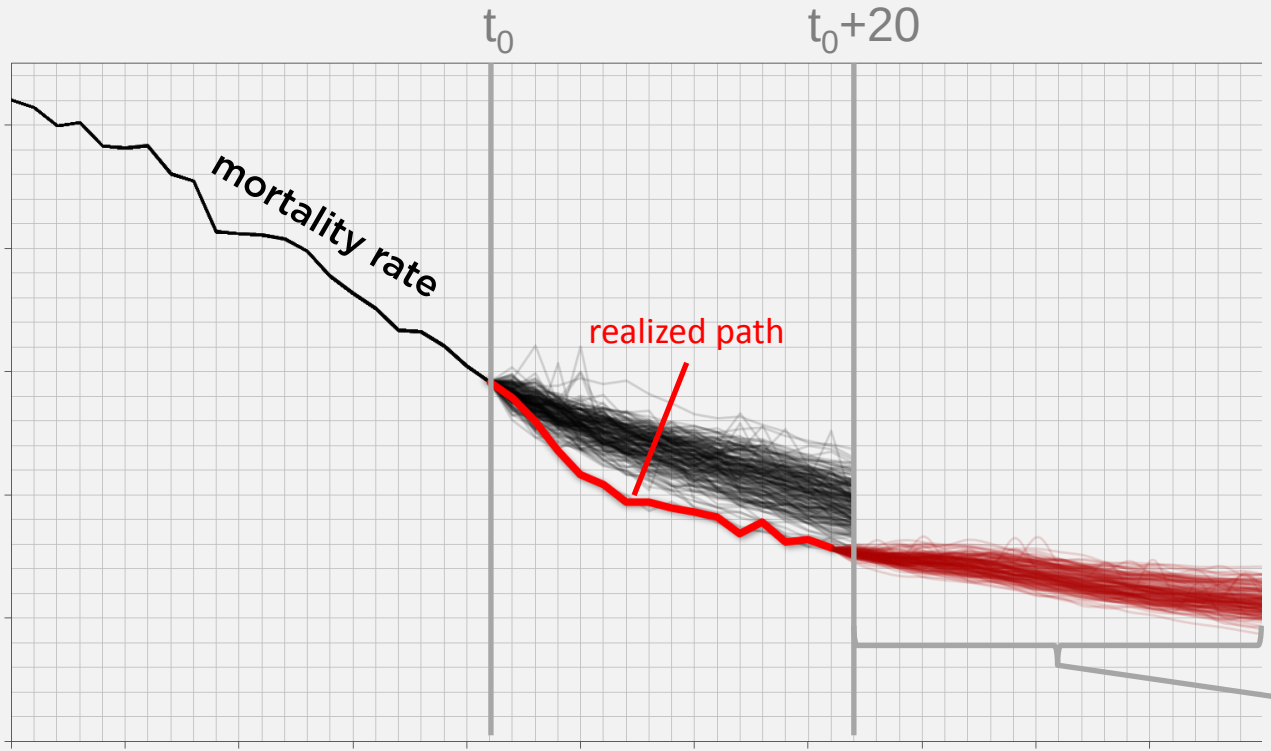
Projecting Commutation Period Mortality



Projection based on "re-parametrized" model

Projected paths over Commutation Period

Projecting Commutation Period Mortality

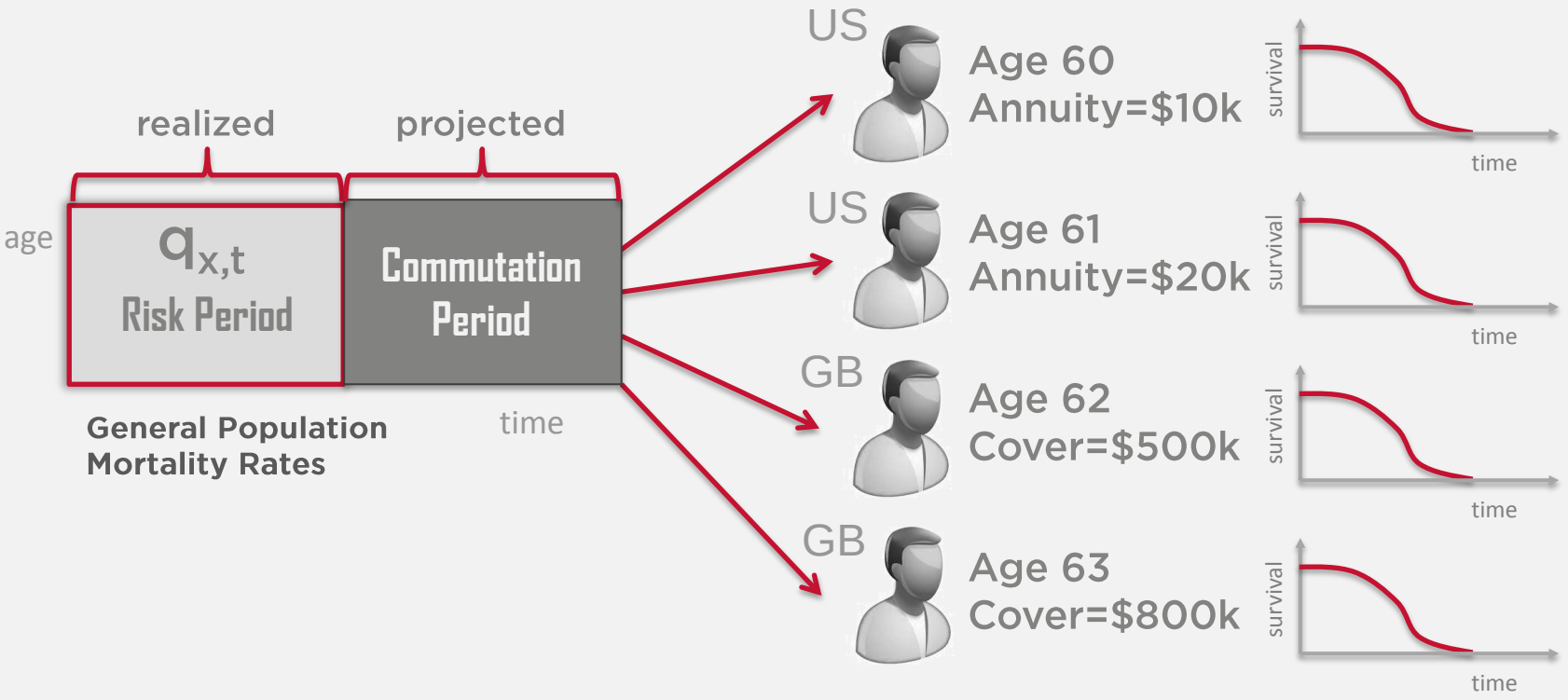


Projection based on "re-parametrized" model

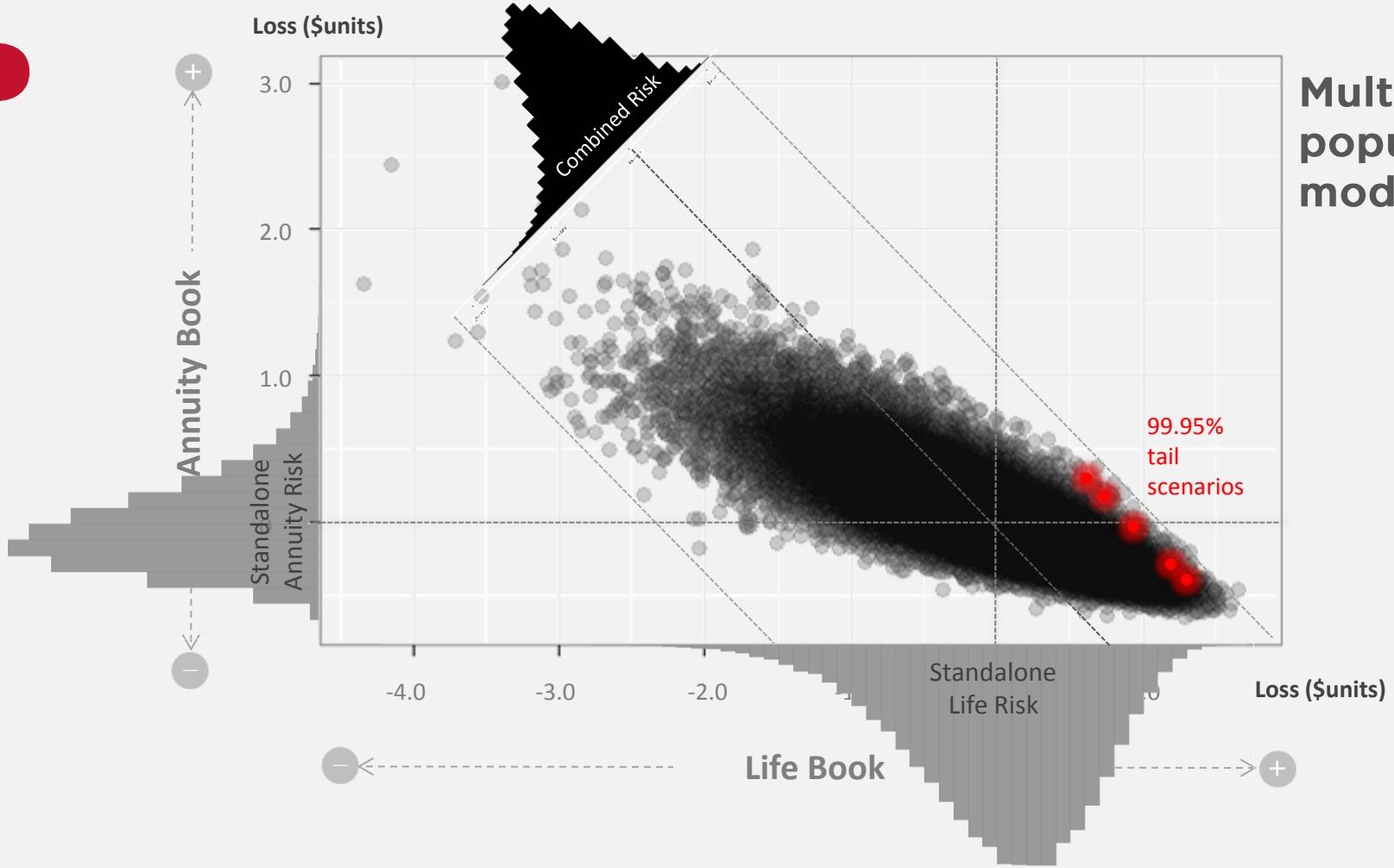
Projected paths over commutation period

Cash Flow Index

Capturing Sponsor Portfolio



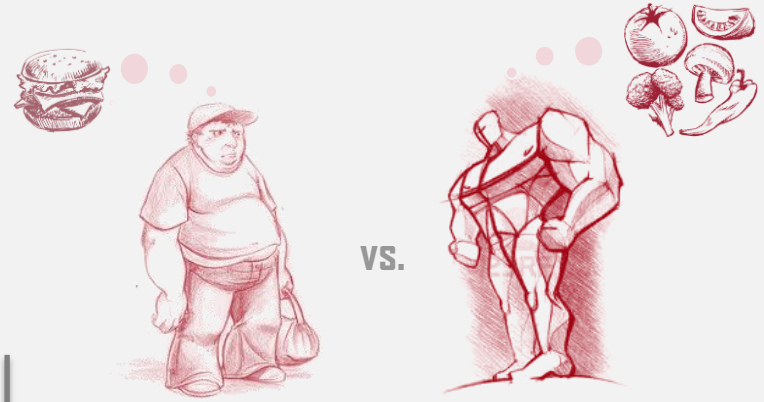
Multi-population modeling

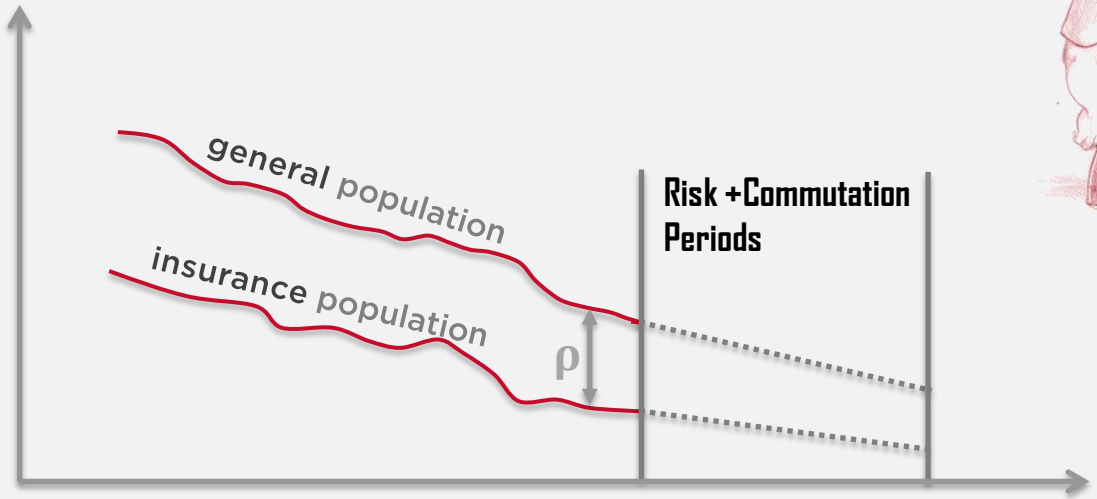


Cash Flow Index

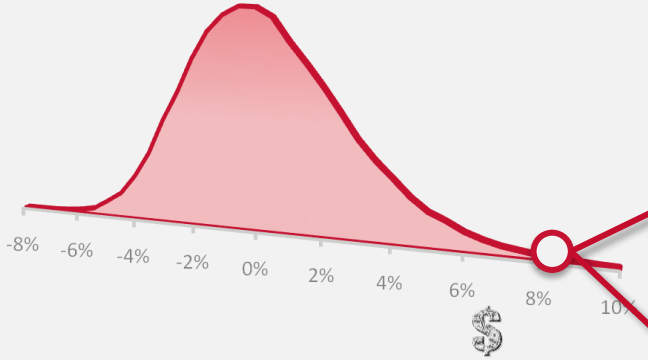
Bridging the Socio-Economic Gap

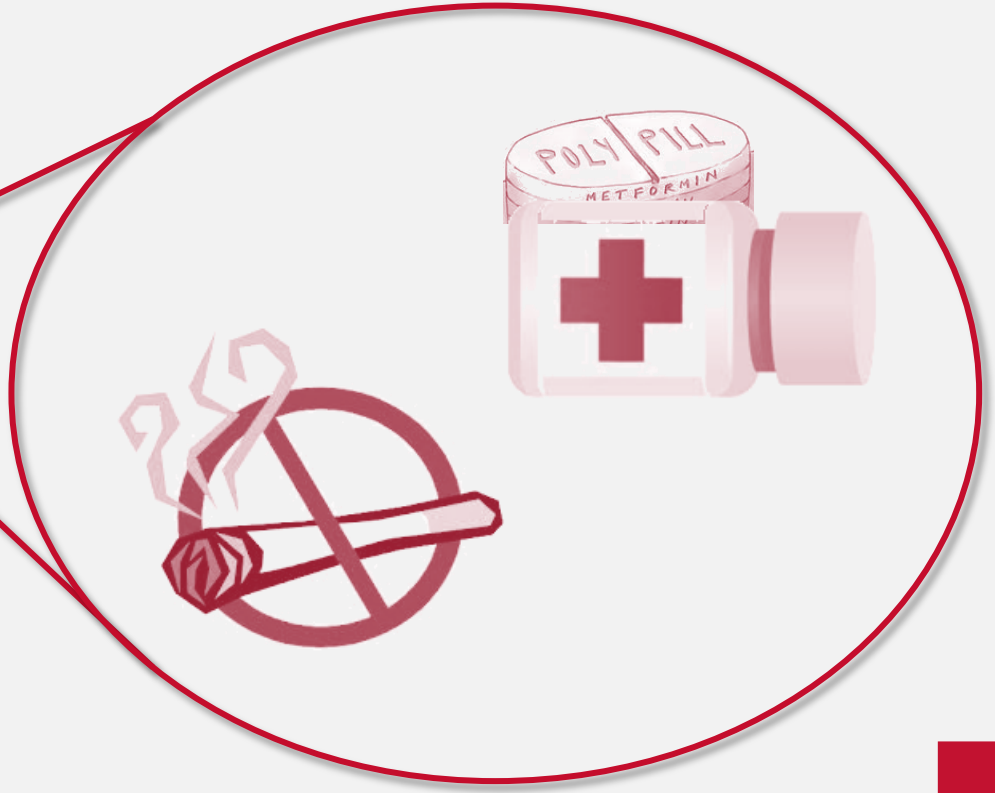
- Sponsor selects "*experience ratio*"
- Used to adjust realized general population q(x,t)





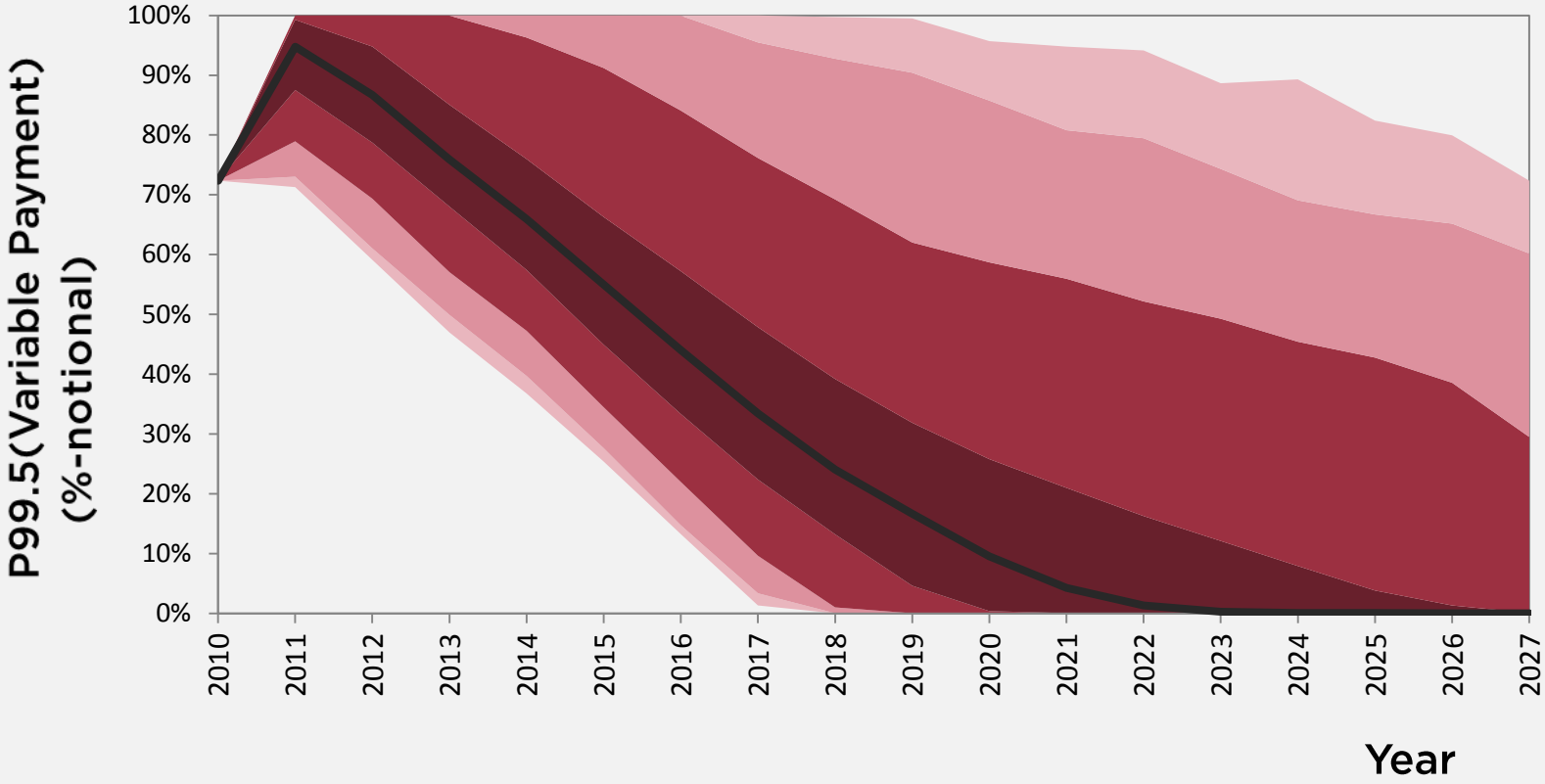
Illustrating Tail Events





What lifestyle / medical advances could drive the cash-flow index into the tail?

Marking to Model

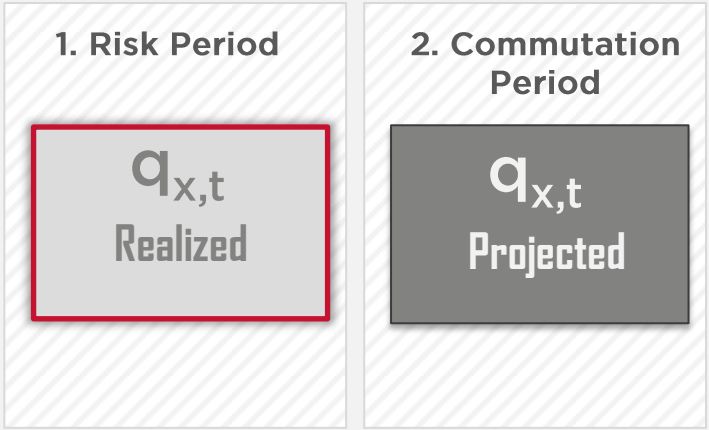


Limiting Complexity for Risk Takers

1. Risk Period

$q_{x,t}$
Realized

Limiting Complexity for Risk Takers



Limiting Complexity for Risk Takers

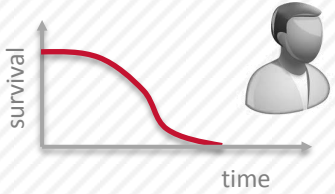
1. Risk Period

$q_{x,t}$ Realized

2. Commutation Period

$q_{x,t}$ Projected

3. Annuitant Survival



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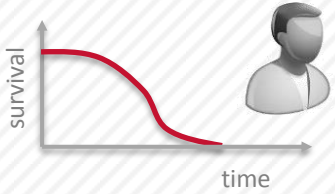


4. Cashflow Index

Limiting Complexity for Risk Takers

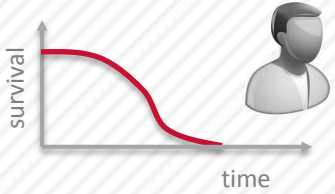
1. Risk Period

$q_{x,t}$ Realized

2. Commutation Period

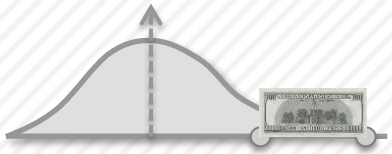
$q_{x,t}$ Projected

3. Annuitant Survival



4. Cashflow Index

5. Attach and Exhaust



Limiting Complexity for Risk Takers

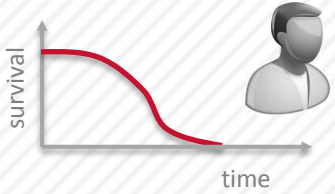
1. Risk Period

$q_{x,t}$ Realized

2. Commutation Period

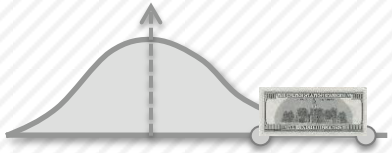
$q_{x,t}$ Projected

3. Annuitant Survival



4. Cashflow Index

5. Attach and Exhaust



6. Variable Payment

Sponsor

Risk Taker

Limiting Complexity for Risk Takers

Pay-off Function

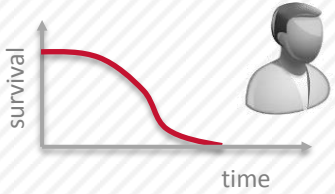
1. Risk Period

$q_{x,t}$ Realized

2. Commutation Period

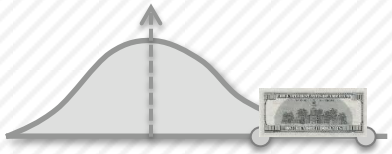
$q_{x,t}$ Projected

3. Annuitant Survival



4. Cashflow Index

5. Attach and Exhaust



6. Variable Payment

Sponsor

Risk Taker

Limiting Complexity for Risk Takers

Limiting Complexity for Risk Takers