CARIBBEAN ACTUARIAL ASSOCIATION

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2016 Annual Conference

Connecting Minds: Sharing Knowledge and Impacting Societies

CAA 26th Annual Conference & 25th Anniversary Celebration

Torarica Hotel
Paramaribo, Suriname

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Pricing for Mortality
Solutions for Changing Environments

MSc Servaas Houben, AAG-FIA, CFA, FRM

Shouben@ennia.com

Servaashouben@gmail.com

+5999 688 1693

2 December 2016

Mortality in the Caribbean

Harmonica: ”**Your friends have a high mortality rate Frank**.”

Agenda

1. Factors (not) affecting life insurance pricing
2. Mortality trends
3. Demographic trends
4. Mortality modelling techniques
5. Pricing effects and risk management
6. Threats and opportunities

1. Factors (not) affecting life insurance pricing

- Factors affecting pricing:
  - Age
  - Gender
  - Smoking status
  - Insured vs uninsured population mortality
  - Diseases (high BMI, cancer, etc)
- Factors not affecting pricing but affecting life expectancy:
  - Social economic status (SES)
    - -> subsidy within DB pension schemes
    - Adverse selection insurance companies
  - Marital status
  - Nr of years smoking and intensity

1. Factors (not) affecting life insurance pricing

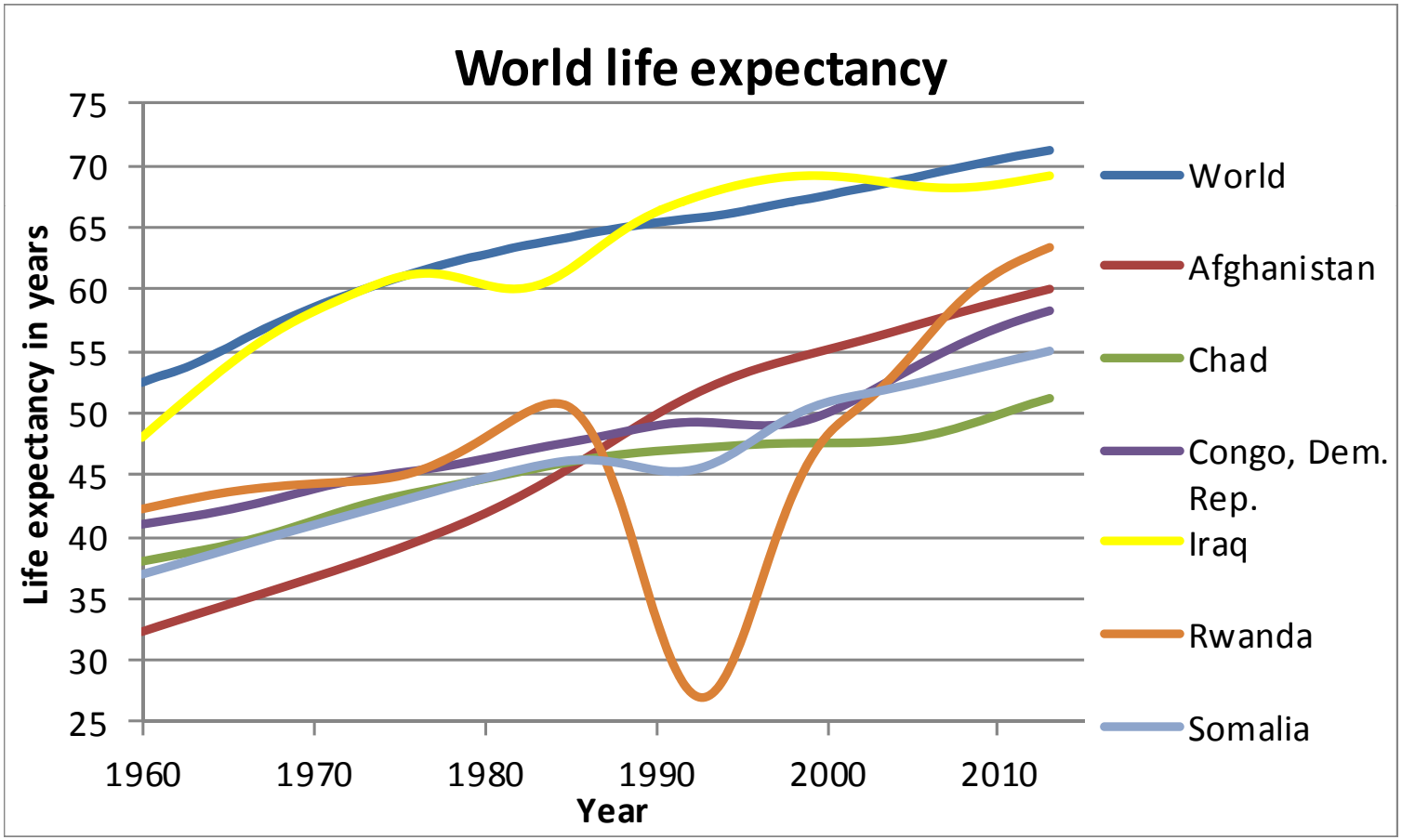
- Correlation ≠ causation
  - Indirect effects (better/less labour intense jobs, healthier life style)

	Life expectancy	
Level of education	Males	Females
Primary school	74.1	78.9
Secondary school – non advanced	76.5	78.6
Secondary school – advanced	78.5	84.9
Tertiary education	81.4	85.3

	Life expectancy from age 65	
Level of education	Males	Females
Primary school	9.1	13.9
Secondary school – non advanced	11.5	13.6
Secondary school – advanced	13.5	19.9
Tertiary education	16.4	20.3

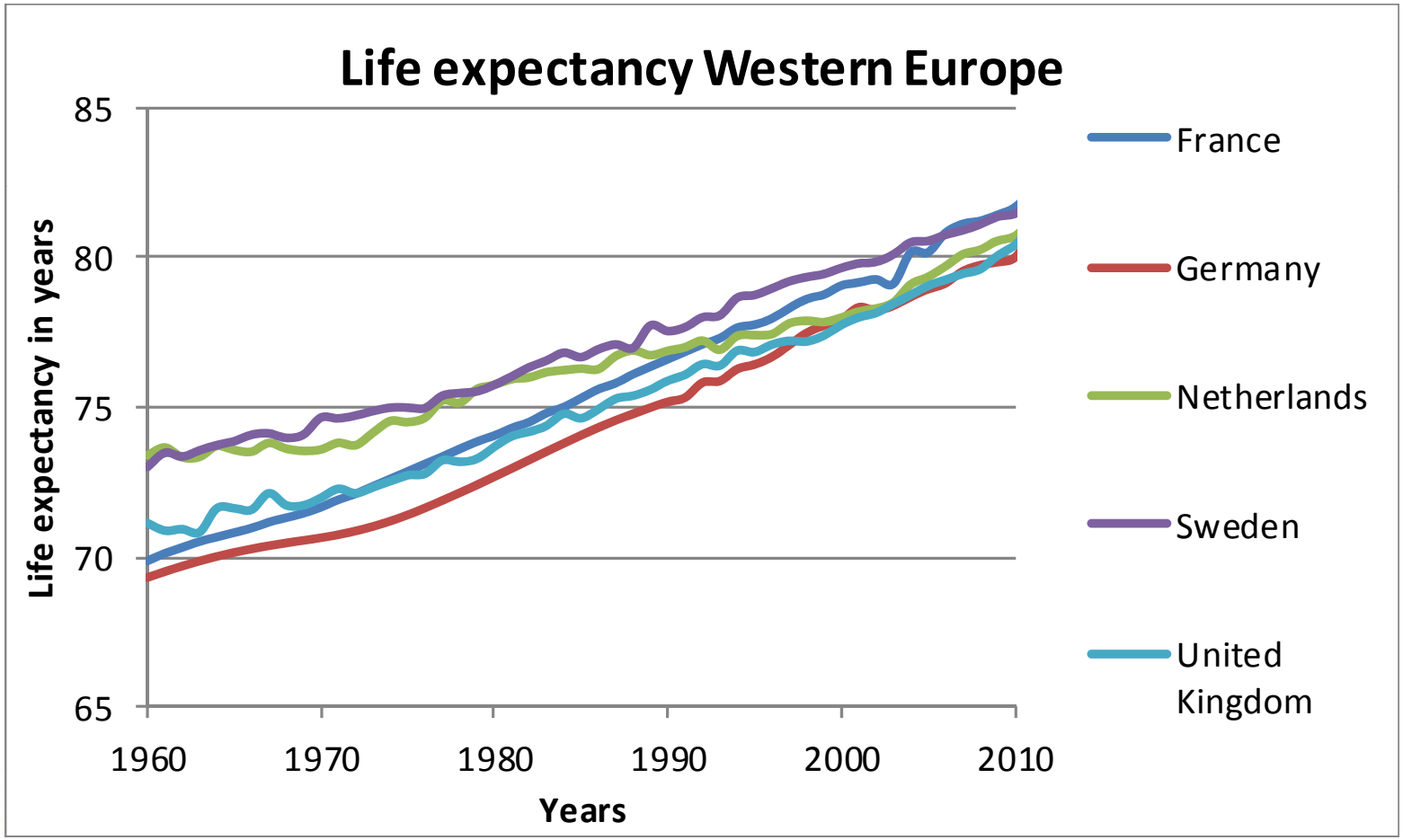
Source: OECD 2013

2. Mortality trends
worldwide trend higher life expectancy



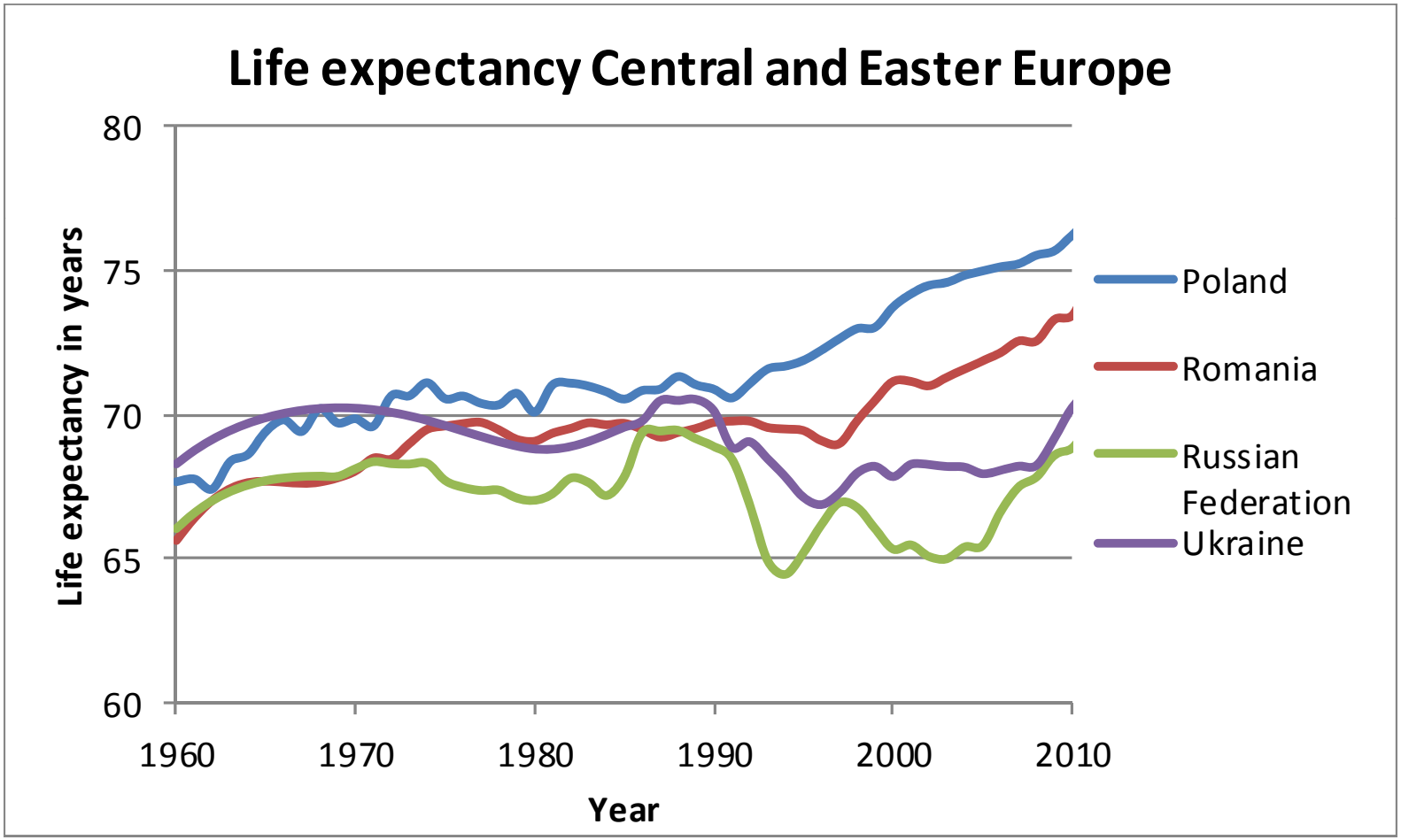
Source: World Bank

2. Mortality trends
extreme trends



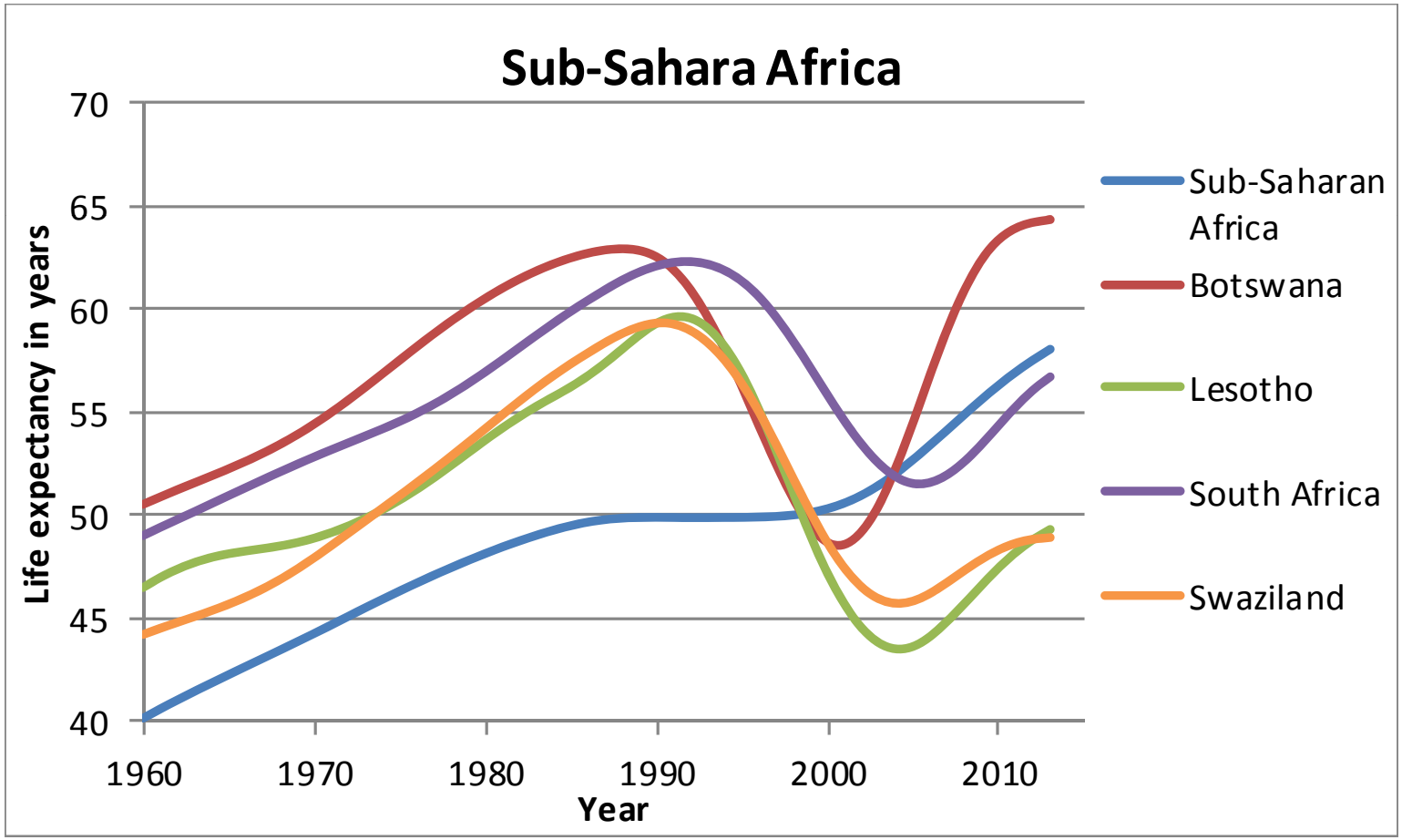
Source: World Bank

2. Mortality trends
regime shifts



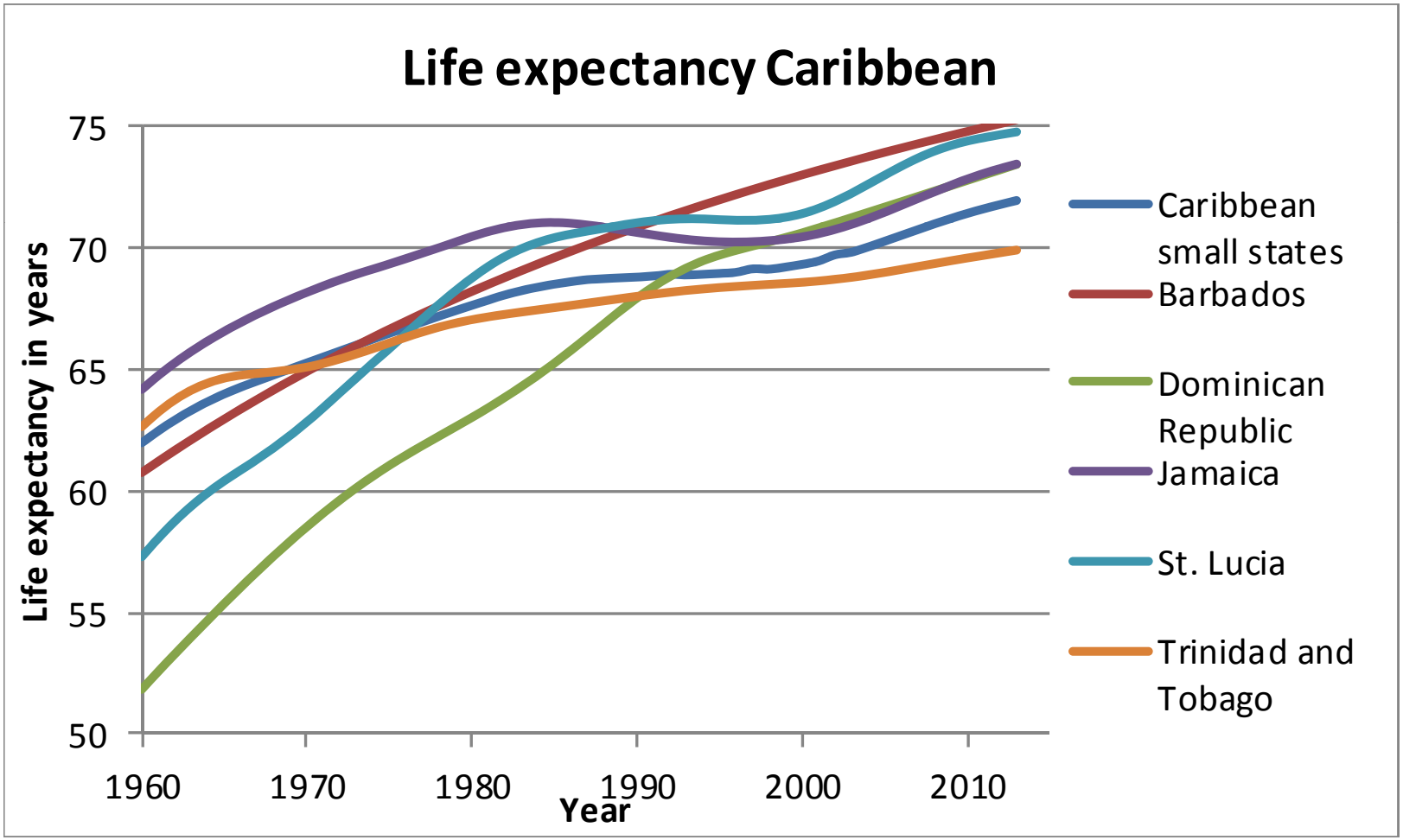
Source: World Bank

2. Mortality trends
epidemics



Source: World Bank

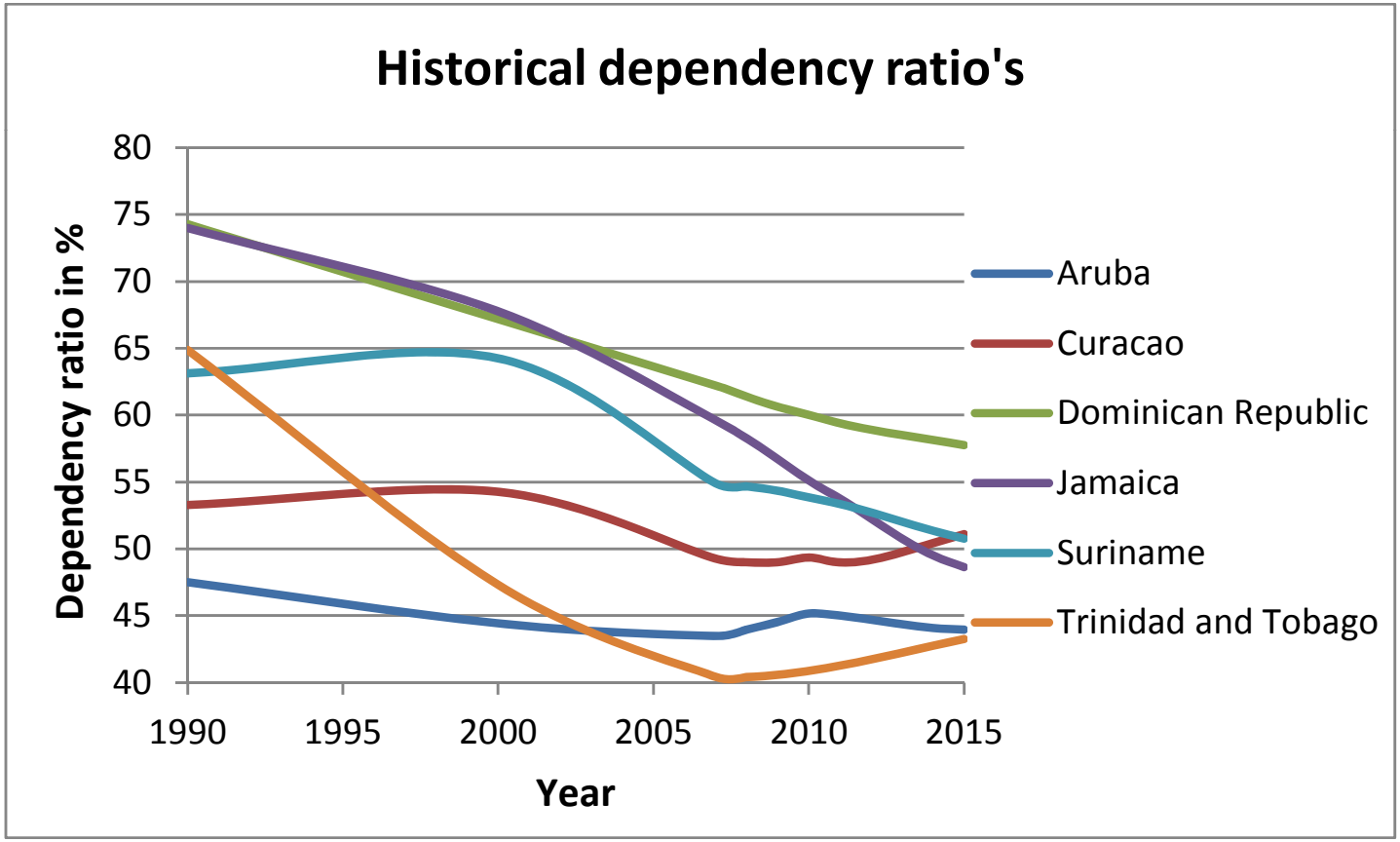
2. Mortality trends
epidemics



Source: World Bank

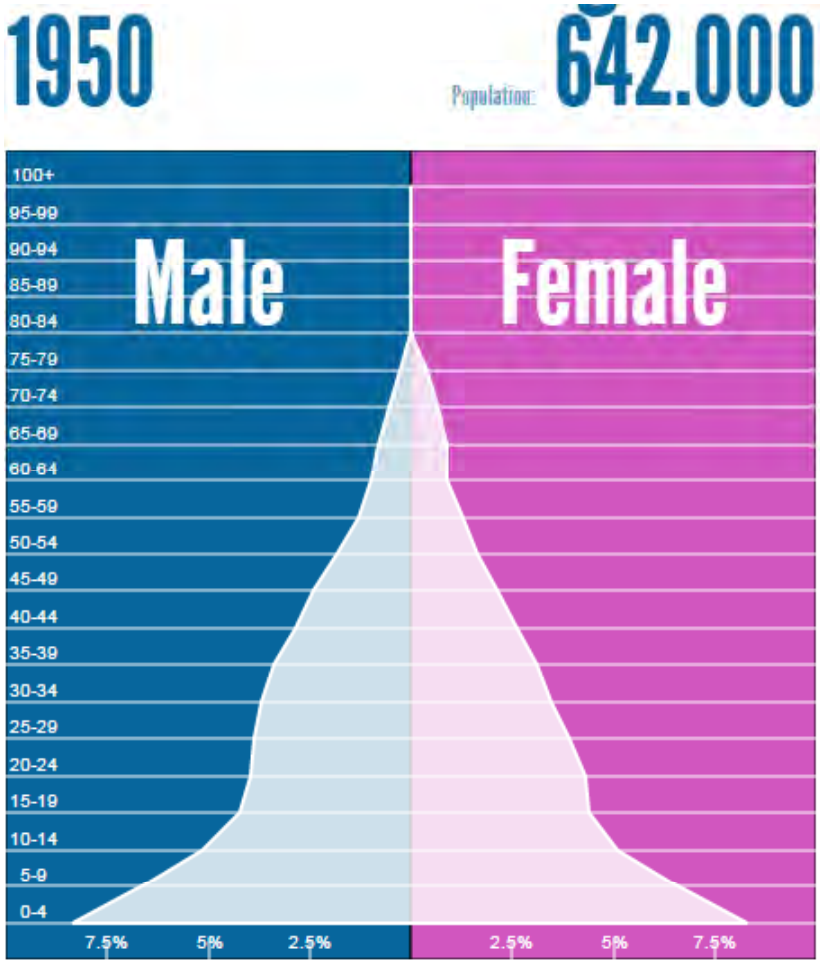
3. Demographic trends
dependency ratio not covering the entire story

- $\text{Dependency ratio} = \frac{dependents\ (age < 14\ \&\ age > 65)}{15 <= age \leq 65}$



Source: World Bank

3. Demographic trends
changing population pyramids – Trinidad & Tobago



Source: http://populationpyramid.net/

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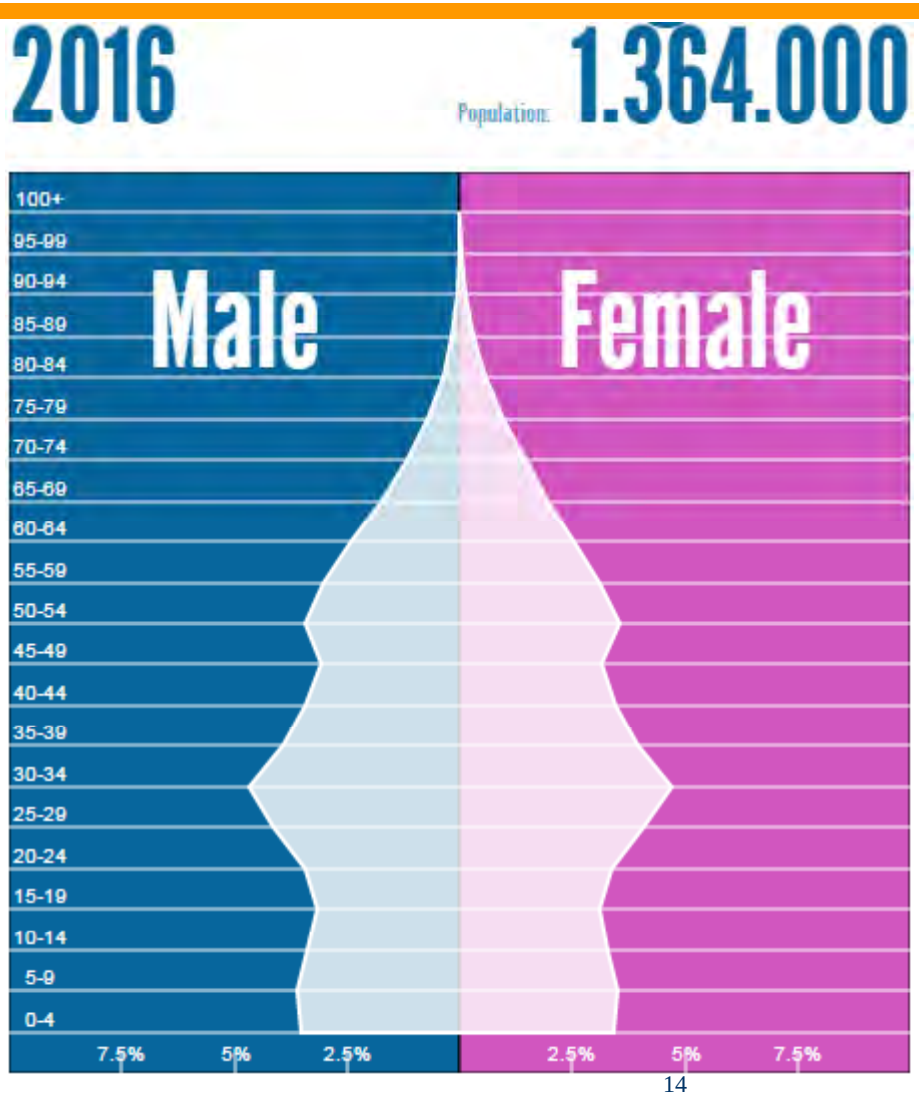

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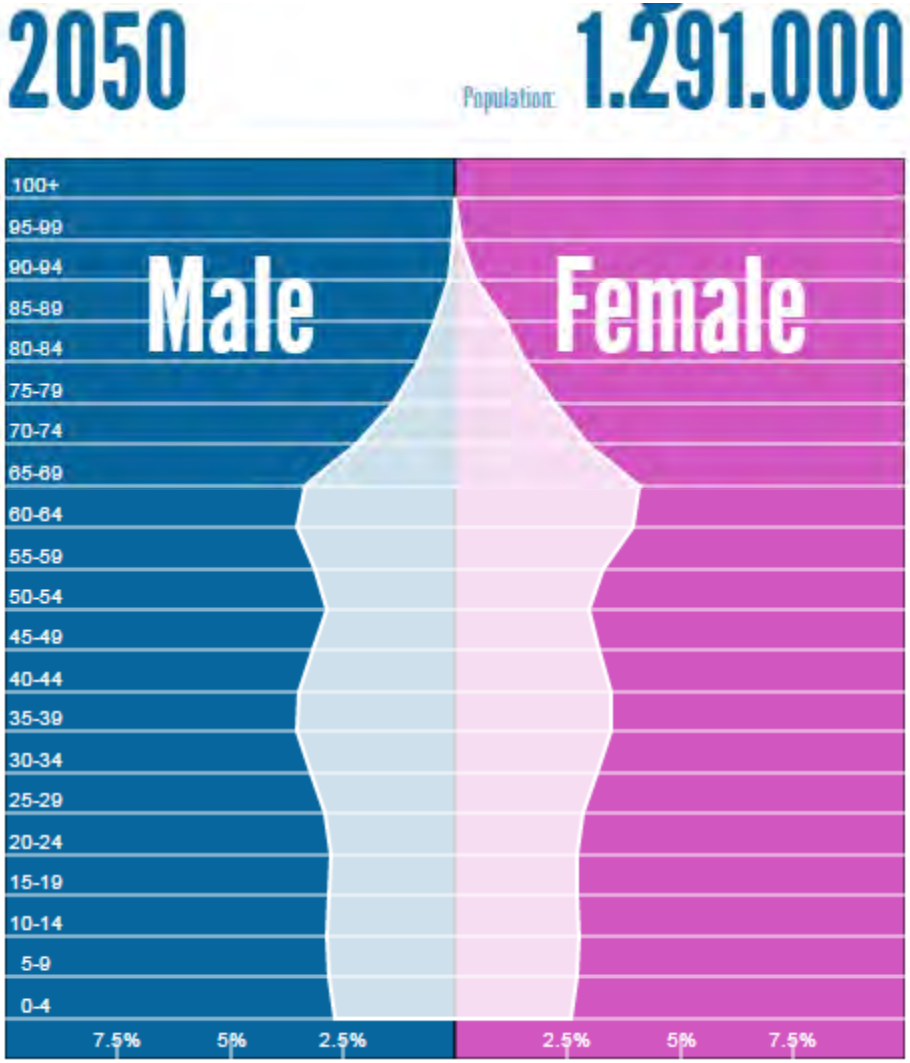


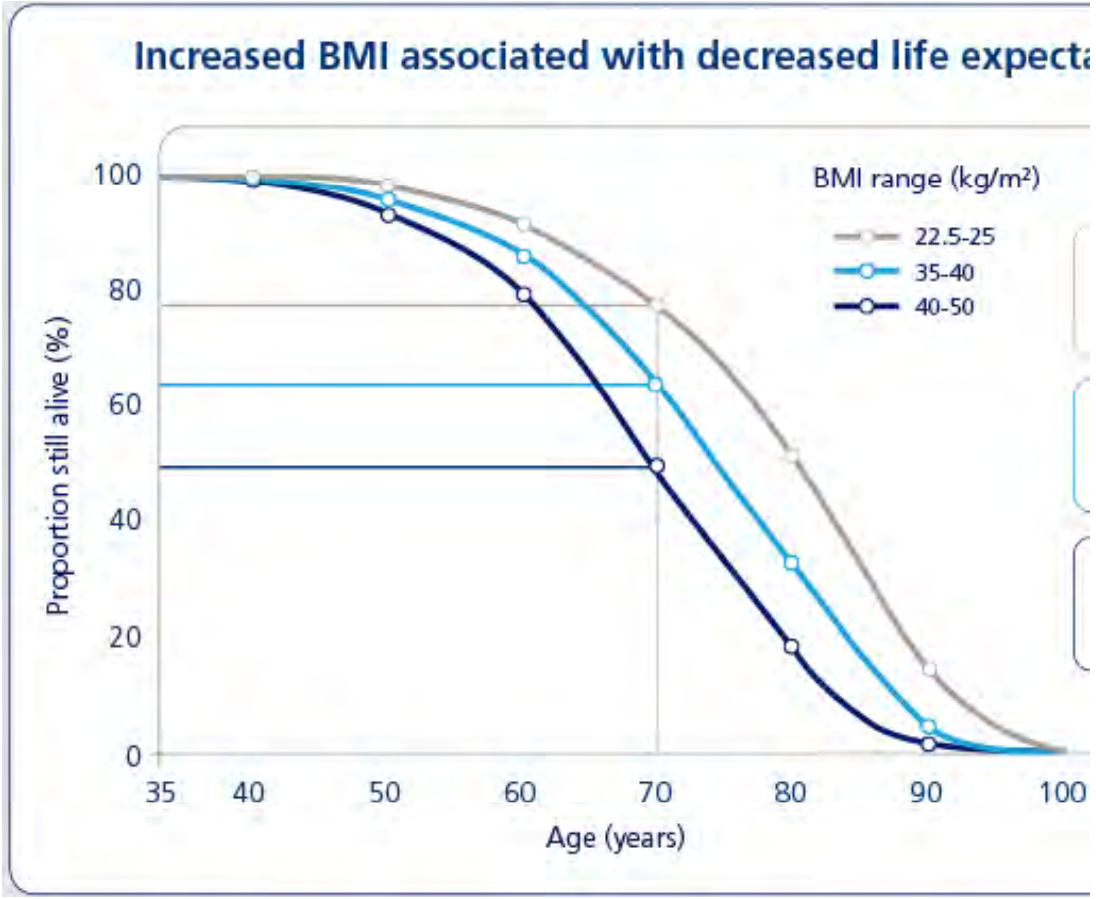
Source: http://populationpyramid.net/

3. Demographic trends
funding and trends Caribbean

- Main impact on pay as you go funded systems e.g. state pensions
- Decreasing impact of changing premium levels DB pension schemes
- Anti-aging drugs like Metformin
- Worldwide trend of women working more hours -> stress and effects on alcohol and smoking

3. Demographic trends
funding and trends Caribbean

- Relatively high levels of BMI, cancer in the Caribbean
  - 6 Caribbean countries in top 24 of highest BMI
  - -> cure (healthcare) vs care (food quality, exercising, etc)
  - Potential effect governments stimulating healthy living: Curacao applies different VAT rates for different foods



4. Mortality modelling techniques

1. Data collection, cleansing, and segmentation
2. Mortality principles
3. Smoothing of data and extrapolation of mortality probabilities
4. Fitting data with population mortality tables (optional)
5. Building in trends

4 Mortality modelling techniques
4.1 Data collection, cleansing, and segmentation

- Several types of data available:
  - Overall population data (Central Bureau of Statistics)
  - Insurance and pension fund data
    - Due to differences in Social Economic Status differences emerge
    - Use overall population data to assess correctness of insurance data results
  - Possible extent data set by including other geographies (WorldBank etc)
  - Even larger countries apply extension of data sets: Netherlands uses Western European region (correlation)

4 Mortality modelling techniques
4.1 Data collection, cleansing, and segmentation

- Determine level of segmentation:
  - Male vs female
  - Age dependent
  - Retired vs non retired (to do)
  - Smoker vs non-smoker (to do)
  - Marital status and SES background not included (yet)
- Be aware of system limitations which may cause issues
- ENNIA dataset 2008-2014:
  - 148.707 policyholders, 471 mortality cases
  - Example in presentation for male mortality rates

4 Mortality modelling techniques
4.2 Mortality principles

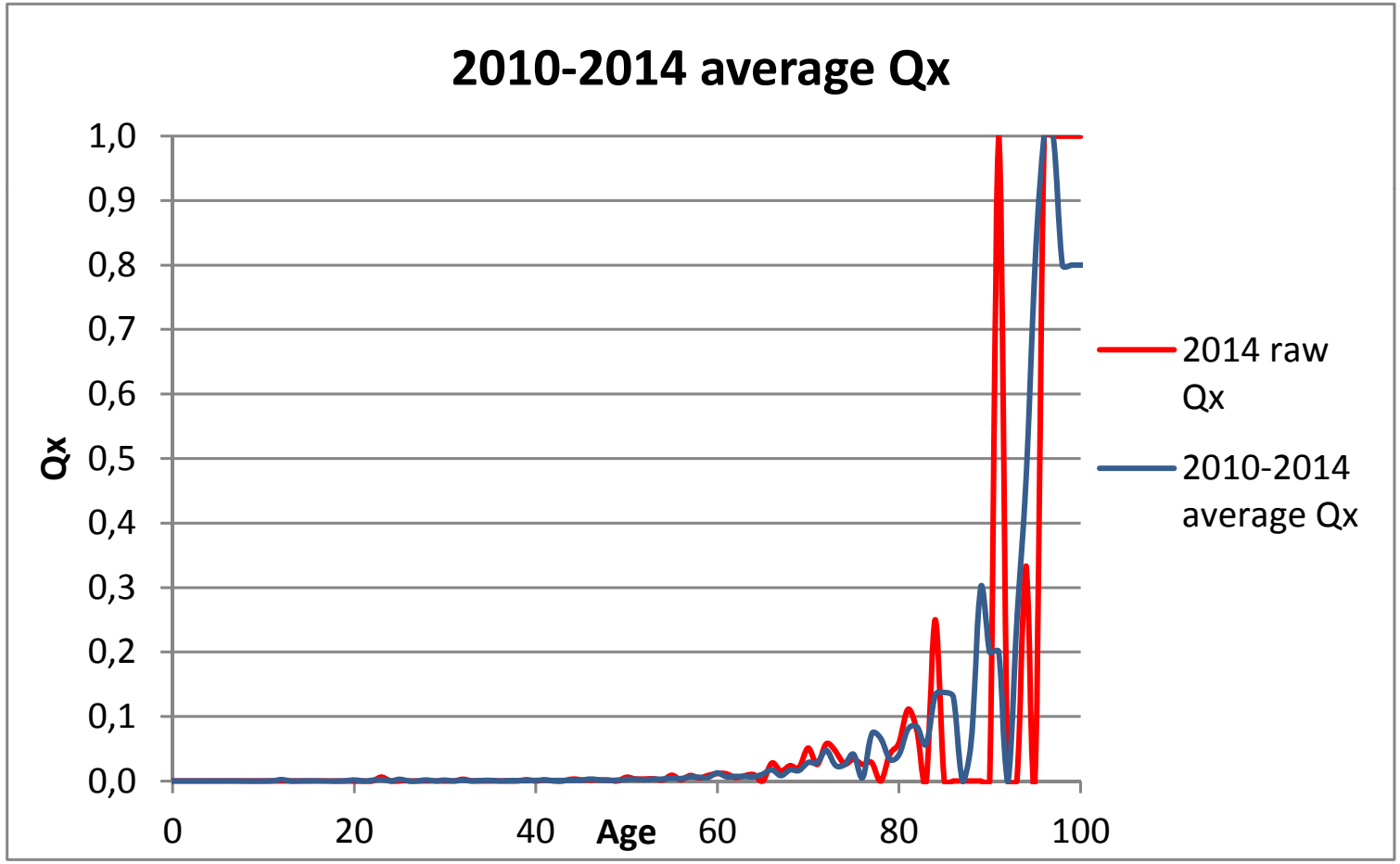
- Best fit lots of time not required: impact q_x for certain year might be limited to overall reserve calculation
- Some general principles to apply to mortality assumptions:
  - Monotonic mortality function: $q_x <= q_{x+1}$
    - But accident hump might happen in early 20s for males
  - Extrapolation after certain age (e.g. 80) has high level of expert judgement while little impact on reserves
  - $q_x => q_y$
  - Building in trend
    - when at time t $q_x <= q_{x+1}$
    - then not time t+n $q_x => q_{x+1}$
  - Limited data (Caribbean) requires more expert judgement

4 Mortality modelling techniques
4.3 Smoothing of data and extrapolation of mortality probabilities

- With limited data sets (e.g. Caribbean) spikes in mortality rates occur
- Raw mortality rates: based on pure data before adjustments
- Actuaries and statisticians want to include some “logical” characteristics to mortality behaviour
  - e.g. increased probability of mortality by age reflected in exponential distribution (Gompertz)
- -> apply several smoothing techniques to raw data
  - Horizontal smoothing over several years (panel data) for estimation mortality probability certain age
  - Vertical smoothing between several ages

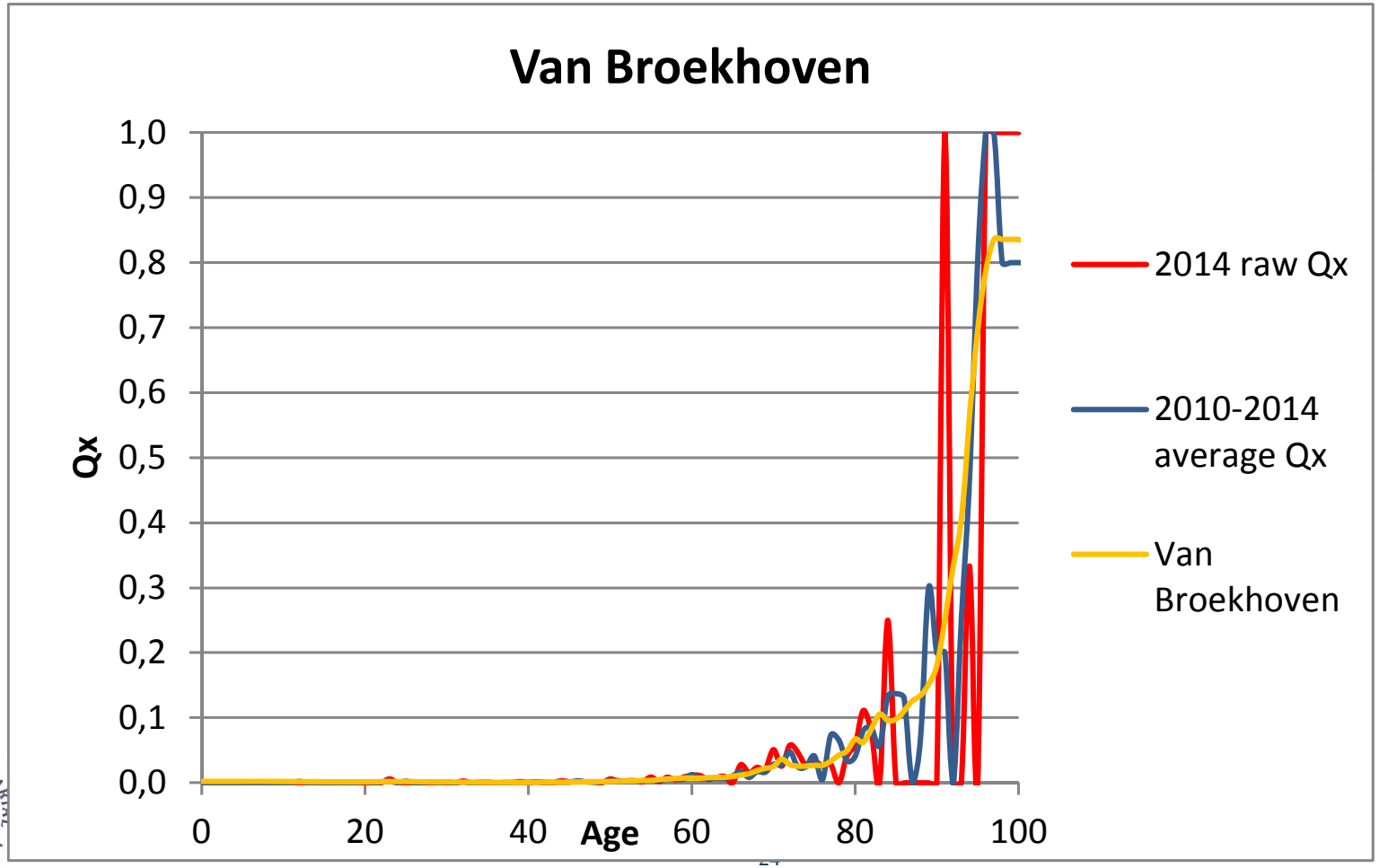
4 Mortality modelling techniques
4.3 Smoothing of data and extrapolation of mortality probabilities

- Example of adjusting raw data to smoothed data (horizontal averaging)



4 Mortality modelling techniques
4.3 Smoothing of data and extrapolation of mortality probabilities

- Example of adjusting raw data to smoothed data (vertical)

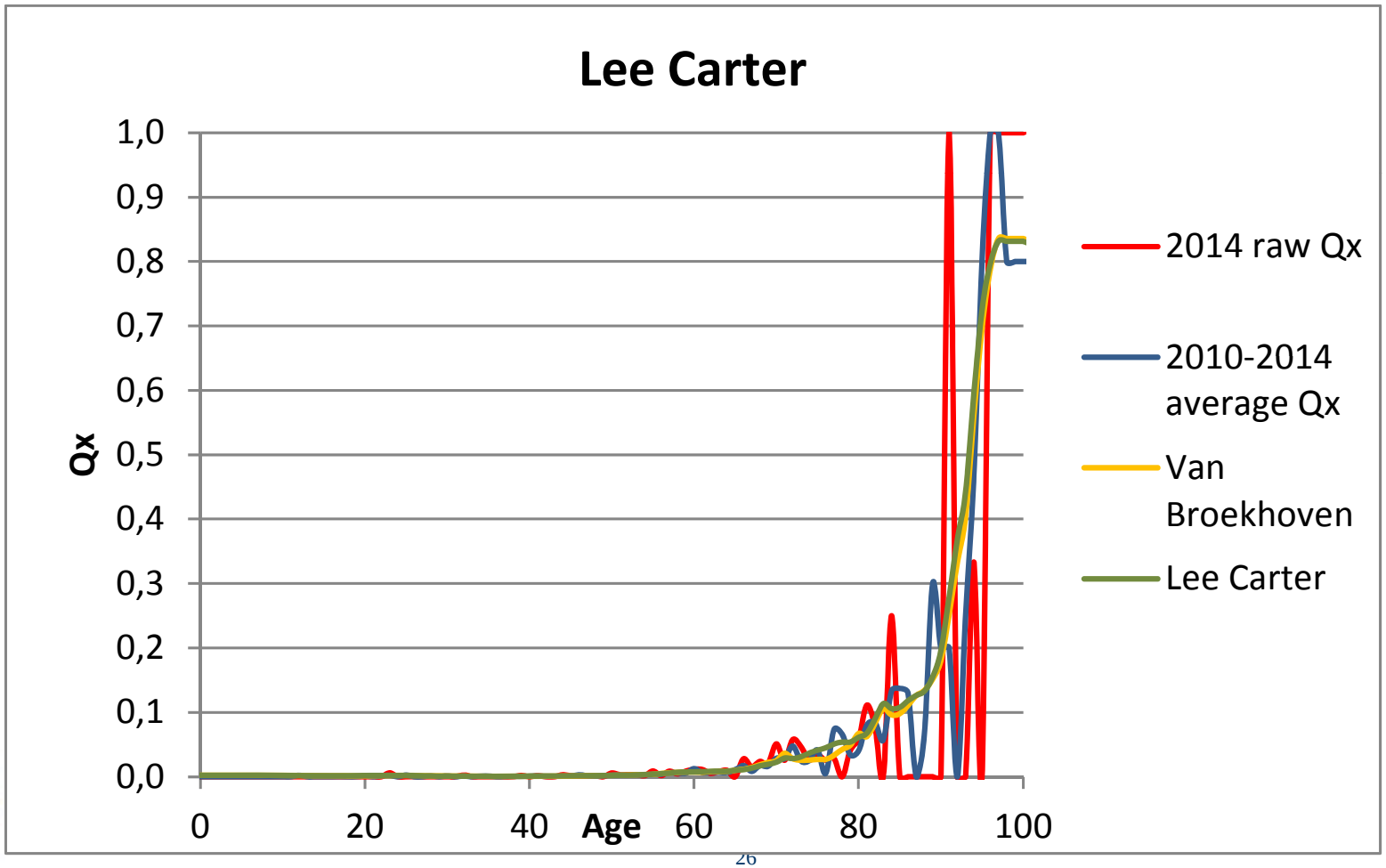


4 Mortality modelling techniques
4.3 Smoothing of data and extrapolation of mortality probabilities

- As mortality rates reflect an exponential pattern, apply a log transform to create a linear pattern
- Use OLS to optimise the constant mortality and age-dependent mortality term
- Lee-Carter is an extension of OLS as it includes a time dependent component which reflects the improvement of mortality rates over time
- $\log m_{xt} = a_x + b_x k_t + e_{xt}$, *where* x *is age, and* t *is time*
- Optional to apply extrapolation after certain ages as insufficient data is available to motivate choices of mortality table

4 Mortality modelling techniques
4.3 Smoothing of data and extrapolation of mortality probabilities

- Example of pattern after Lee Carter

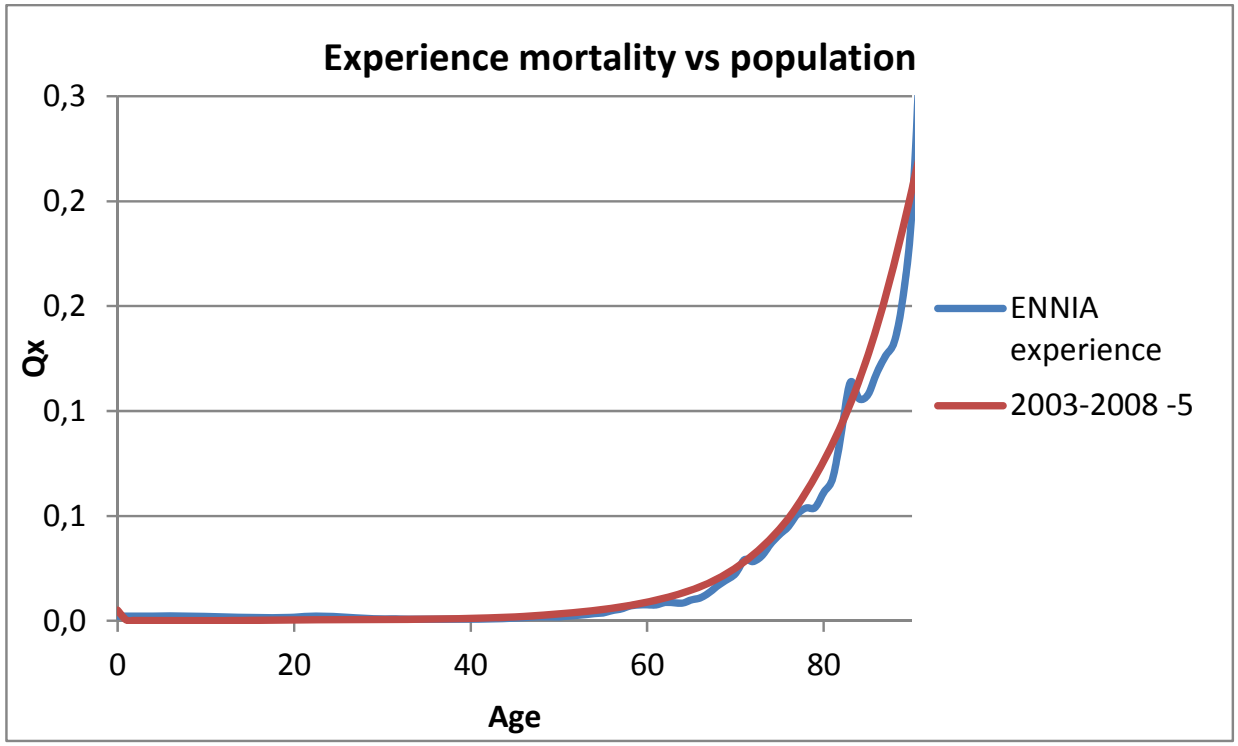


4 Mortality modelling techniques
4.4 Fitting data with population mortality tables (optional)

- Stakeholders may prefer overall population mortality table (p_x) compared to fund specific mortality table (p_{ex})
  - More comfortable/widely known and benchmark (sense check)
  - Audit
  - Sales/clients
- Use of OLS to choose best fit
  - E.g. take sum of $n_x (p_{ex} - p_x)^2$
  - Optional to choose maximum value for x
- However choice of suitable table remains very subjective, especially with limited data
  - US, Canada, or Western European mortality table?
  - Even when there is a fit, do the trends behave similarly?

4 Mortality modelling techniques
4.4 Fitting data with population mortality tables (optional)

Population mortality table	8590	0005	0308
Age correction	-9	-6	-5
Sum of square differences	5,4674	4,5308	4,1886



4 Mortality modelling techniques
4.5 Building in trends

- Use local trends and worldwide trends
- Backtesting trends by recurring mortality studies

Age				
From	To	Qx 2008-2012	Qx 2010-2014	% difference
11	20	0,00022	0,00038	171,09%
21	30	0,00110	0,00091	82,55%
31	40	0,00097	0,00063	65,34%
41	50	0,00224	0,00187	83,66%
51	60	0,00712	0,00657	92,22%
61	70	0,02310	0,02547	110,22%

5 Pricing effects and risk management
5.1 Saving vs term assurance

- Main effect on changing mortality assumptions for term assurance products
- Example switching from Dutch 2000-2005 mortality table to 2003-2008 (male, capital 10.000), lumpsum payment

	3%_0005	3%_0308	% increase
Annuity – age 60	167,539	172,226	2.80%
Term assurance – age 35 – 25 years	444.53	413.77	-6.92%
Pure endowment– age 35 – 25 years	5,534	5,539	0.10%

5 Pricing effects and risk management
5.2 Combination with low interest rate environment

The Matrix: Race to Negative Bond Yields										
Country	1-Year	2-Year	3-Year	4-Year	5-Year	6-Year	7-Year	8-Year	9-Year	10-Year
Switzerland	-0.84	-0.94	-0.92	-0.84	-0.77	-0.66	-0.58	-0.48	-0.39	-0.32
Japan	-0.18	-0.19	-0.20	-0.18	-0.17	-0.17	-0.12	-0.09	-0.03	0.05
Germany	-0.47	-0.51	-0.46	-0.40	-0.28	-0.24	-0.14	-0.04	0.11	0.24
Netherlands		-0.48	-0.47	-0.39	-0.29	-0.17	-0.06	0.09	0.22	0.39
Finland	-0.45	-0.47	-0.41	-0.34	-0.19	-0.13	0.02	0.14	0.29	0.53
Austria	-0.40	-0.46	-0.43	-0.34	-0.27	-0.13	0.05	0.19	0.36	0.53
Belgium	-0.43	-0.44	-0.36	-0.31	-0.21	-0.07	0.08	0.40	0.58	0.74
France	-0.41	-0.44	-0.37	-0.27	-0.15	-0.04	0.12	0.24	0.44	0.61
Sweden	-0.50	-0.57		-0.40	-0.12		0.13			0.48
Denmark		-0.24			0.02	0.31				0.55
Ireland	-0.18		-0.18	-0.03	0.09	0.28	0.48	0.75	0.90	1.03
Spain	-0.07	0.00	0.13	0.34	0.62	0.96	1.23	1.40	1.65	1.78
Italy	-0.07	0.06	0.14	0.37	0.60	0.90	1.08	1.26	1.56	1.70
Portugal	-0.01	0.55	1.13	1.67	1.99	1.69	2.60	3.02	3.21	3.40

Pension Partners

5 Pricing effects and risk management
5.2 Pressure on annuity market

Male annuity rates	4%_8590	3%_8590	4%_0308	3%_0308
Age 25	21.35	25.46	21.89	26.29
Age 45	17.05	19.39	18.07	20.73
Age 65	10.25	11.06	11.54	12.53

Male annuity rates	4%_8590	3%_8590	4%_0308	3%_0308
Age 25	-	4.11	0.53	4.94
Age 45	-	2.34	1.02	3.67
Age 65	-	0.80	1.28	2.28

5 Pricing effects and risk management
5.2 Pressure on annuity market

	Year			
Age	2014	2015	2016	2017
20	0.000385	0.000375	0.000366	0.000357
21	0.000409	0.000399	0.000390	0.000380
22	0.000406	0.000398	0.000389	0.000381

	Price immediate annuity (3% discount rate)	
Age	No longevity trend	Longevity trend
25	26.94	28.02
45	21.77	23.09
65	13.93	14.89

5 Pricing effects and risk management
5.2 Pressure on annuity market

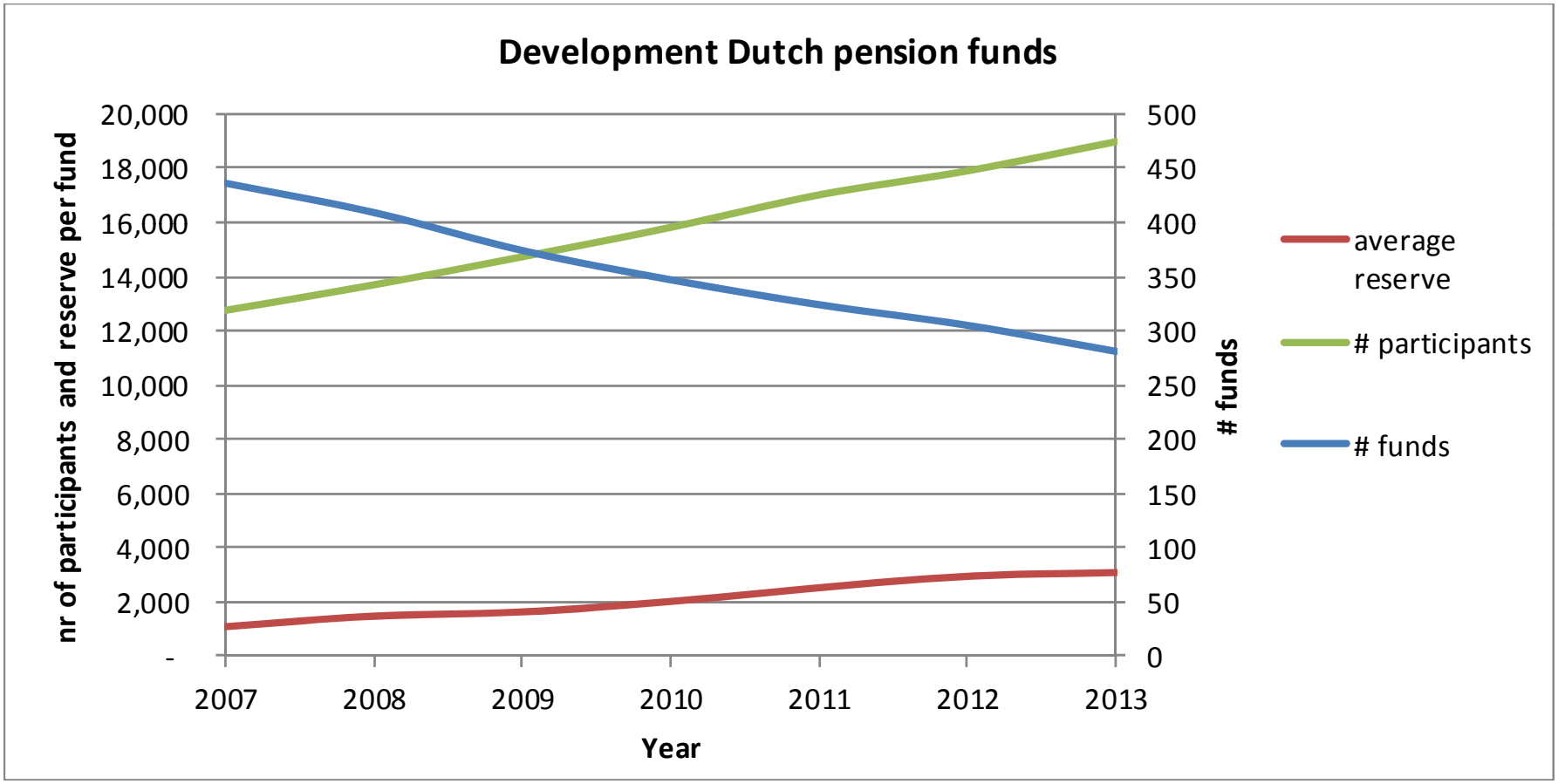
- Possible solutions building in mortality trend:
  - Trend table
  - Existing table with correcting factor (may differ between different genders and age groups)
  - Main advantage using trend table is yearly automatic adjustment of pricing

6 Threats and opportunities
6.1 General pension fund

- Governance and increased solvency and reporting requirements increases cost of running pension funds
  - Smaller funds look for alternatives
- Solution: combine smaller pension funds in overall fund with one central
  - Reporting
  - Risk management
  - Board, etc
- Fund can be administered by insurance company
- Within general pension fund still possible to maintain pension fund specific risk tolerance and benefit level (e.g. indexation, pension plan)

General pension fund charges admin fee to participating funds

6 Threats and opportunities
6.1 General pension fund - trends



6 Threats and opportunities
6.1 General pension fund - benefits

Policyholder/pension fund	Insurance company
Low operating costs	Economies of scale
Qualified board members, governance risk management	Investment risk and mortality/longevity risk born by policyholder
Fund specific risk tolerance and benefit level	Admin fees

6 Threats and opportunities
6.2 Variable retirement benefits

- Guarantees on return and longevity are becoming more and more expensive
  - Capital buffers required for guarantees (Solvency II)
  - Reinsurance of longevity in Caribbean challenging due to small markets and little diversification benefits
- -> shift (some of the) burden to policyholders by making payments flexible
- Further alternatives:
  - Collective asset management or individual based
  - Sharing of longevity risk between generations

6 Threats and opportunities
6.2 Variable retirement benefits - benefits

Policyholder	Insurance company
Flexibility asset management depending on risk tolerance	Reduced capital buffers
Flexibility retirement benefits	Limited or no investment risk
(Potential) higher benefits as reserve remains invested during retirement	Limited or no longevity risk

6 Threats and opportunities
6.3 Product development

- Less hard guarantees, more risk towards policy holder
  - Fewer defined benefit schemes
  - Profit sharing with profits contracts at end of contract period (less reversionary bonuses, more terminal bonuses)
  - Guarantees for shorter time periods to take uncertainty on longevity effects into account
- Combine several insurance elements to reduce effects longevity, e.g. spouse pension
  - combination male policyholder and female spouse works well
  - combination female policyholder and male spouse does not work well as probability older male outliving younger female is small

6 Threats and opportunities
6.4 Reinsurance

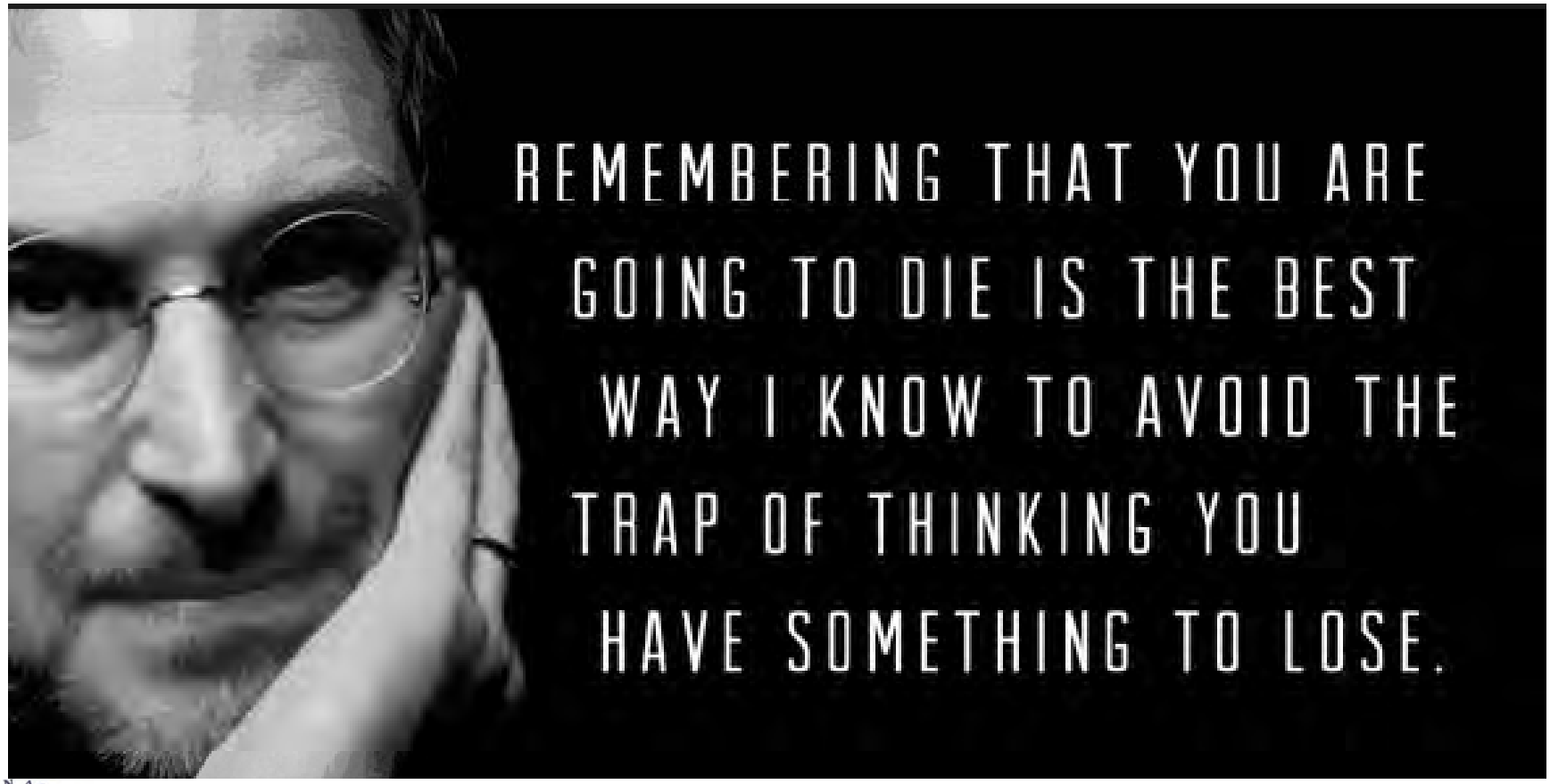
- Longevity swaps
  - Works well in regions with lots of data/policyholders
  - Insurance company retains fixed leg (fixed duration payments), reinsurance company floating leg (variable duration payments)
    - Example:
      - Life expectancy from 65 is 15 years
      - Insurance company pays 15 years + risk premium
      - Reinsurance company pays until death
    - Potential credit/default risk reinsurance company
  - Mortality assumptions either based on overall population mortality or client experience mortality data

Risk/asset transfer (part VII)

6 Threats and opportunities
6.5 Client segmentation

- Extend pricing factors
  - Include Social Economic Status
    - Measuring challenges
    - Privacy concerns
  - Marital status
    - Causal relationship or reflecting other effects?

Conclusion


REMEMBERING THAT YOU ARE
GOING TO DIE IS THE BEST
WAY I KNOW TO AVOID THE
TRAP OF THINKING YOU
HAVE SOMETHING TO LOSE.

About me

Servaas Houben is heading the actuarial team of ENNIA in Willemstad, Curacao. He studied econometrics in the Netherlands and worked in life insurance for the first four years of his career. Thereafter, he worked in Dublin and London. Besides actuarial, Servaas completed the CFA and FRM qualifications, and regularly writes on his blog, for CFA digest and (actuarial) magazines.

Email: servaashouben@gmail.com

Blog: http://actuaryabroad.wordpress.com

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Population pyramids: http://populationpyramid.net/