Milliman

Funding pension plans with longevity swaps: how risky is the future?

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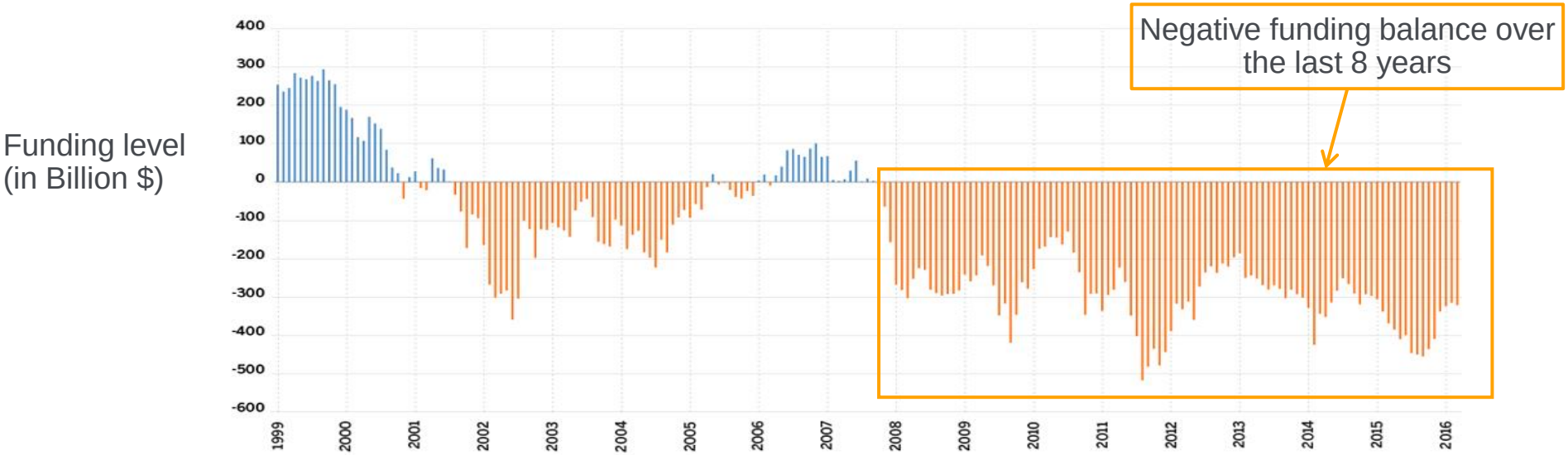
Agenda

1. **Pensions and longevity risk**
2. Longevity risk transfer solutions
3. Case study: how risky is the future?

Pensions and longevity risk

Funding status of private pension plans

- The defined benefit pension plans are facing several risks:
  - Investment risk (stocks, interest rates, inflation,…)
  - Risks related to the economic and regulatory context
  - **Longevity risk**
- Below the '*Milliman 100 Pension Funding Index*', which represents the funding status of the 100 largest defined benefit pension plans in the United States



Pensions and longevity risk

Longevity risk

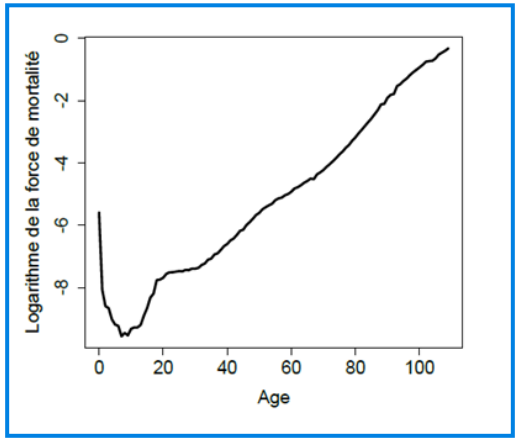
- Longevity risk is the risk that pension plan participants live longer than expected
  - This famous definition implicitly relies on actual demographic projections, therefore on appropriate methods and models
  - In other words, it assumes that **the measure of risk itself is free of uncertainty**
- Below several **key factors** often taken as influencers of future longevity trends:
  - Medical environment
  - Reduction in smoking
  - Reduction in cardio-vascular diseases
  - Treatment of some cancers
  - On the long term: treatments specific to aging (regenerative medicine)
- The factors underlying longevity are complex – in this context it is necessary to capture the **uncertainty related to its dynamics over time**

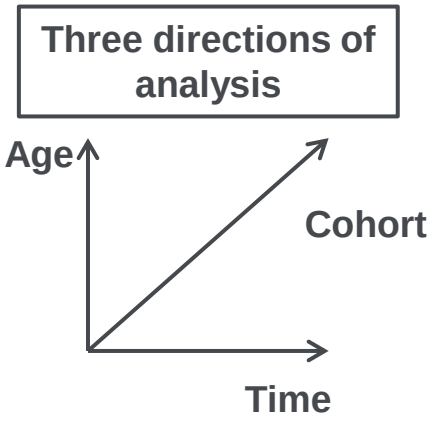
Pensions and longevity risk

Understanding mortality

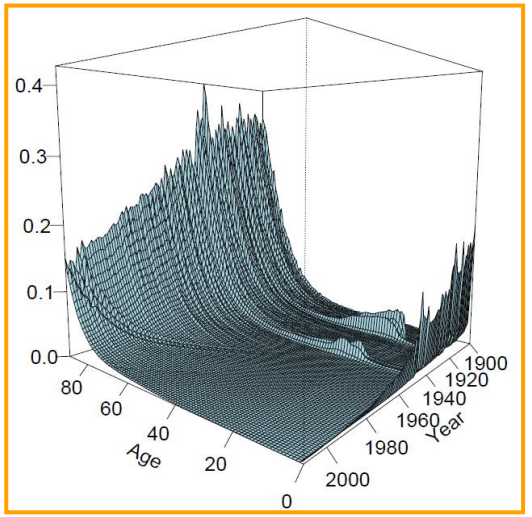
- Below some insightful graphs on past mortality

Age structure (log scale)



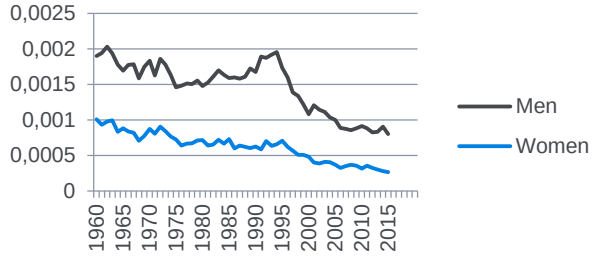


Age x time complexity

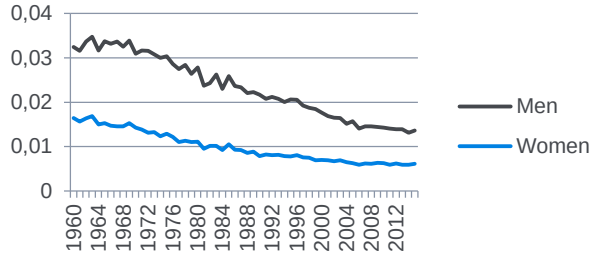


Decrease of death probabilities over time at several ages

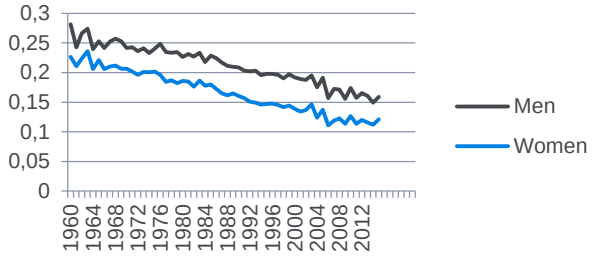
Death probability at age 30



Death probability at age 65



Death probability at age 90



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2. **Longevity risk transfer solutions**
3. Case study: how risky is the future?

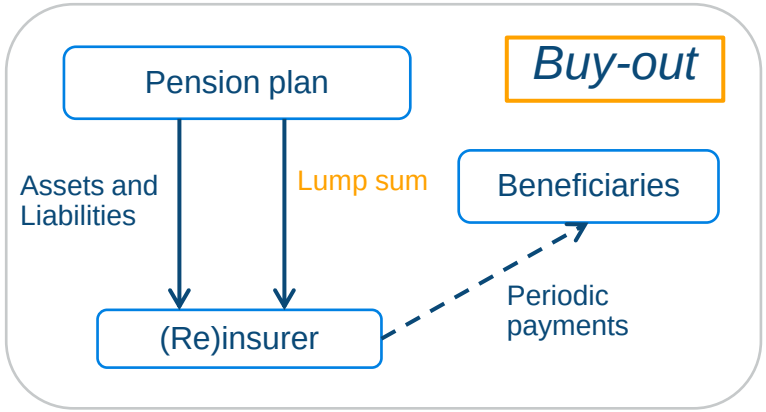
Longevity risk transfer solutions

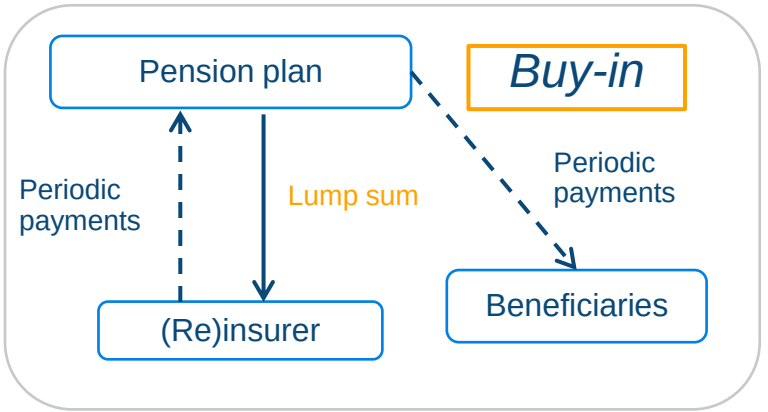
Pensions and longevity risk

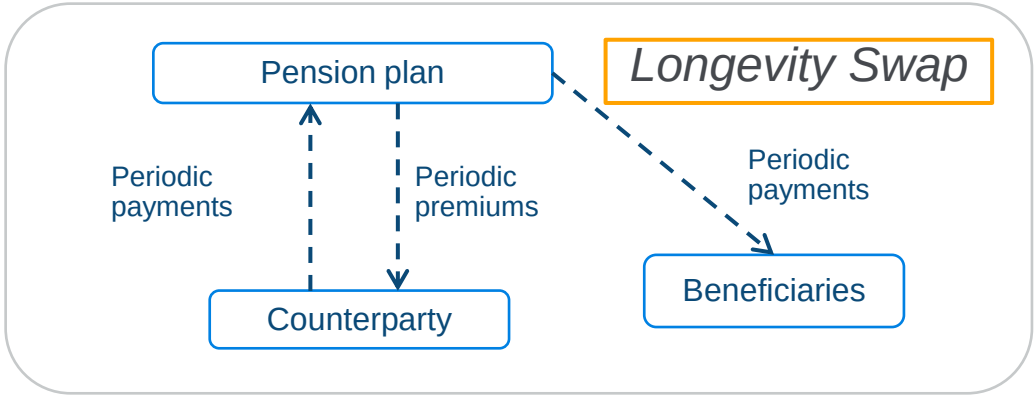
- Companies embedding internal pension plans have in common that part of their activity can be linked to that of a **pure life insurance company** (we often refer to 'pseudo-life-insurance companies') ; but **several differences** should be noted:
  - The management of **long term risks** (including longevity) is the **core job** of insurance and reinsurance companies
  - The Solvency 2 regulatory environment requires (re)insurance companies to **hold important capital reserves** in front of risk
  - (Re)insurance companies can leverage a **diversification effect,** such as between longevity risk and other products **related to mortality risk**
- The need for pension plans to transfer longevity risk is clear – to achieve this, several strategies can be set, such as:
  - ***Buy-out*: full transfer of the assets and liabilities** to an insurer, which then disappear from the balance sheet
  - ***Buy-in*: the insurer pays periodic payments** to the pension plan, providing a precise match of the defined benefit plan's benefit – this cover enters as an asset in the pension plan balance sheet
  - ***Swap***: the pension plan pays **periodically** a **fixed premium and receives a variable payment equal or close to the realized benefits**

Longevity risk transfer solutions

Buy-in, buy-out, swap







Longevity risk transfer solutions

Some examples of transactions

- In 2015, 4 of the 100 largest US plans (Milliman 100 Index) have chosen Buy-out solutions:

Company	Amounts
Pfizer	$2.6 B
Verizon Communications Inc.	$2.3 B
Kraft Heinz	$1.6 B
Hewlett Packard	$1.1 B

- Other defined benefit pension plans have chosen longevity swaps, such as:

Company	Counterparty	Volume	Year
Bell Canada Pension Plan (BCE Inc.)	Sun Life Financial Inc. (plus SCOR & RGA Re)	CAD$5 B	2015
AXA UK Pension Scheme	RGA Re	£2.8 B	2015
Scottish & Newcastle Pension Plan	Friends Life (plus Swiss Re)	£2.4 B	2015
Manweb Pension Scheme	Abbey Life	£1 B	2016
RAC (2003) Pension Scheme	SCOR SE	$900 M	2015
Two Pirelli pension plans	Zurich / Pacific Life Re	£600 M	2016

Cumulate activity for defined benefit pension plans risk transfer market (2007->2015 included)

Agenda

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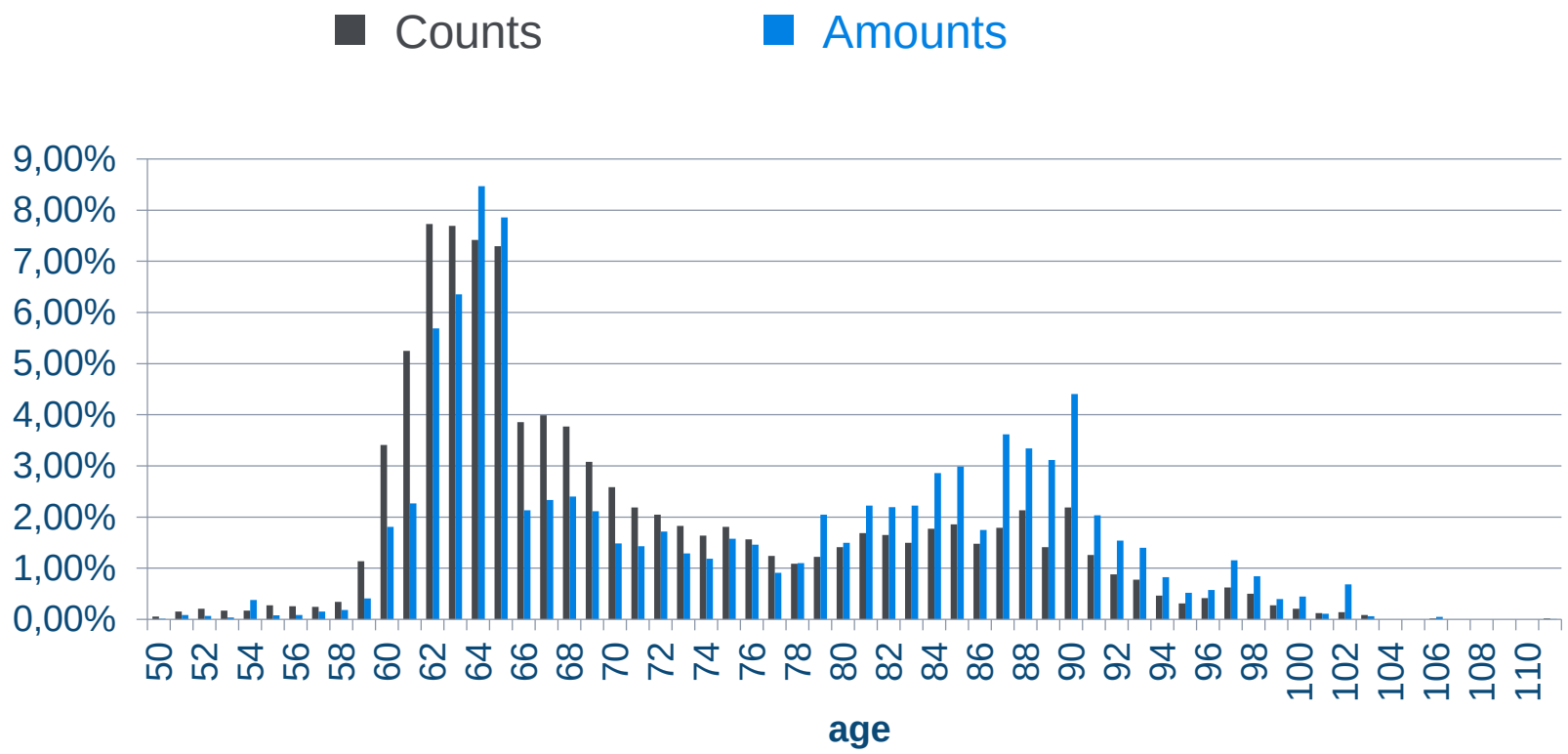
3. **Case study: how risky is the future?**

Case study: how risky is the future?

Portfolio considered

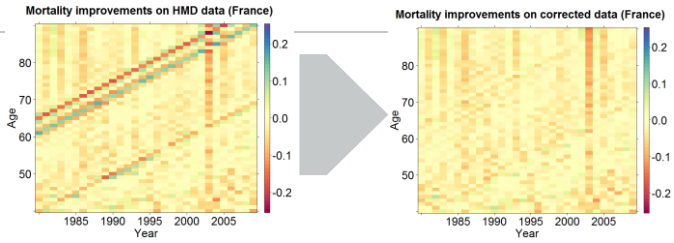
- This case study is based on a real pension portfolio represented below:



Note that this is an illustrative case study with simplified assumptions

Case study: how risky is the future?

Challenge #1: mortality data quality (1/2)



- Our research on **mortality data reliability** started with the analysis and correction of **abnormal cohort effects**
  - We first developed a method to **correct mortality data anomalies** for countries for which deep fertility histories at the monthly time scale are available
  - We then developed an **extended statistical method** to tackle fertility data deficiency
  - This allows us to provide **corrected tables for all countries included in the famous Human Mortality Database**
- **Milliman Papers** on this topic:
  - *Improving HMD mortality estimates with HFD fertility data.* Presented at Longevity 12 and submitted to the North American Actuarial Journal.
  - *Enjeux de fiabilité dans la construction des tables de mortalité nationales.* L'Actuariel, janvier 2017.
  - *Reliability issues in the construction of national mortality tables for the general population: What you should know (*http://fr.milliman.com/insight/2017/)
- **External collaborations** on this topic:
  - The impact of mortality data anomalies on an internal model, with M. Habart, F. Balland and T. Popa (AXA GRM), presented at 'Congrès des Actuaires', 23 juin 2017
  - Two mathematical papers in preparation with M. Hoffmann and P. Jeunesse (Univ. Paris Dauphine), already presented at several national and international conferences

Case study: how risky is the future?

Challenge #1: mortality data quality (2/2)

- Computation of the fixed payment of the swap (price) depending on **age (on 01/01/2012), maturity and data quality:**

On crude mortality data

Maturity\Age	60	65	70	71	75	80
10	0,8921	0,8461	0,7893	0,7608	0,6794	0,5242
15	0,8063	0,7294	0,6396	0,5965	0,4815	0,2947
20	0,6936	0,5848	0,4672	0,4150	0,2880	0,1248
25	0,5541	0,4200	0,2924	0,2411	0,1332	0,0342
30	0,3959	0,2561	0,1445	0,1066	0,0420	0,0050
35	0,2395	0,1218	0,0500	0,0314	0,0074	0,0003

*On **corrected** mortality data*

Maturity\Age	60	65	70	71	75	80
10	0,8919	0,8465	0,7793	0,7660	0,6793	0,5265
15	0,8060	0,7300	0,6242	0,6044	0,4812	0,2968
20	0,6932	0,5855	0,4479	0,4240	0,2869	0,1260
25	0,5533	0,4210	0,2728	0,2491	0,1325	0,0348
30	0,3951	0,2566	0,1292	0,1123	0,0414	0,0050
35	0,2383	0,1218	0,0421	0,0338	0,0072	0,0003

Relative deviation

Maturity\Age	60	65	70	71	75	80
10	0,0%	0,0%	**-1,3%**	**0,7%**	0,0%	0,4%
15	0,0%	0,1%	**-2,4%**	**1,3%**	-0,1%	0,7%
20	-0,1%	0,1%	**-4,1%**	**2,2%**	-0,4%	1,0%
25	-0,1%	0,2%	**-6,7%**	**3,3%**	-0,6%	1,9%
30	-0,2%	0,2%	**-10,6%**	**5,3%**	-1,5%	0,9%
35	-0,5%	0,0%	**-15,9%**	**7,6%**	-2,8%	1,1%

Generations **born around 1940** present a high sensitivity to the quality of the underlying data

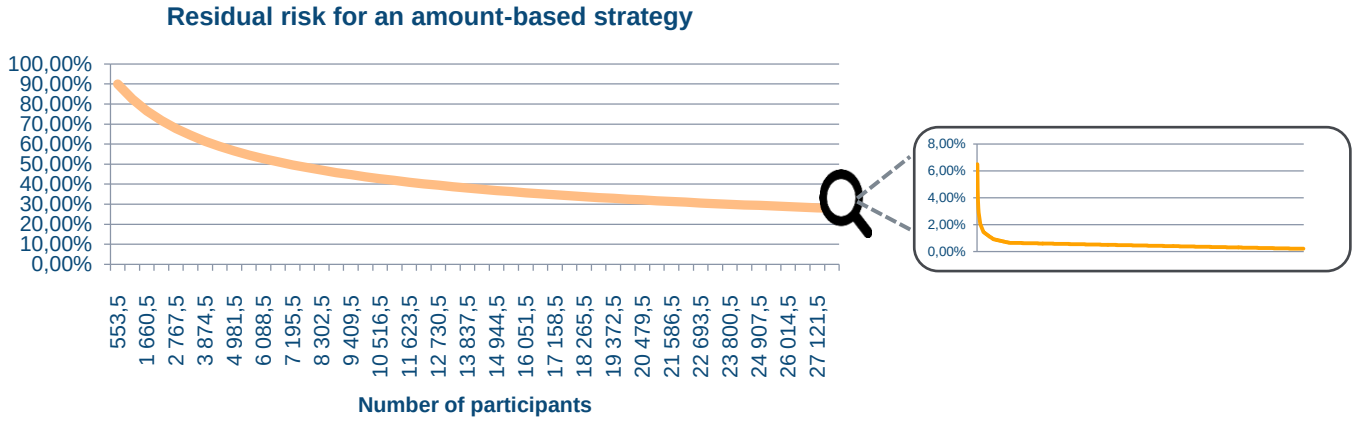
-> the error **increases with maturity**

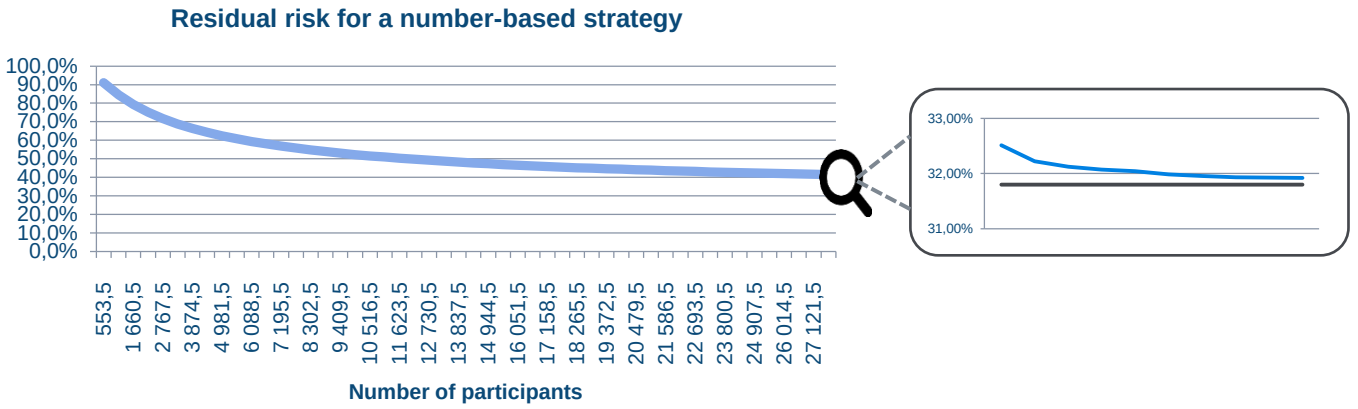
Use here of a standard stochastic mortality model

Case study: how risky is the future?

Challenge #2: partial hedging due to plan size & heterogeneity

- We present below the residual risk for the pension plan as a function of the **portfolio size**, and the **type of strategy** (number vs amounts):



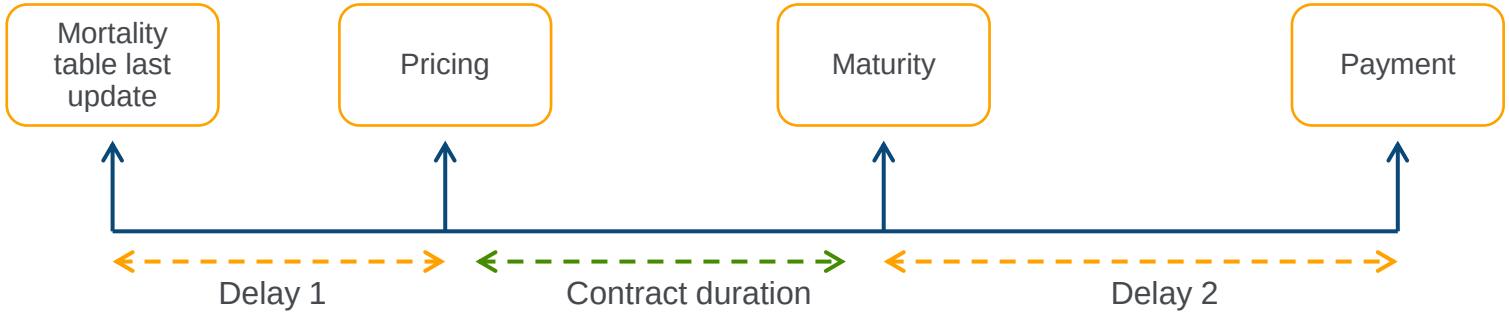


- These two graphs show that an **amount-based strategy** is always better compared to a **strategy based on numbers**, and quantifies the spread between both (**pensions heterogeneity**)
- For an amount-based strategy, the **residual risk vanishes** as the portfolio size increases
- For a **number-based strategy**, residual risk converges to some value around 32% → this corresponds to the **heterogeneity of amounts distribution** of the portfolio

Case study: how risky is the future?

(Open) challenge #3: Lag in mortality data release

- Consider an S-forward contract, which exchanges the **realized mortality** in a given period against some fixed reference mortality ; the 4 following dates can be identified :
  - **Mortality table last update date**: The date on which the last mortality data was released.
  - Pricing date: Contract establishment date, where the fixed leg is priced.
  - Contract's maturity date: Reference date for realized mortality to determine the variable leg.
  - **Payment date**: Date on which fixed and variable legs are exchanged, after the realized mortality is known.

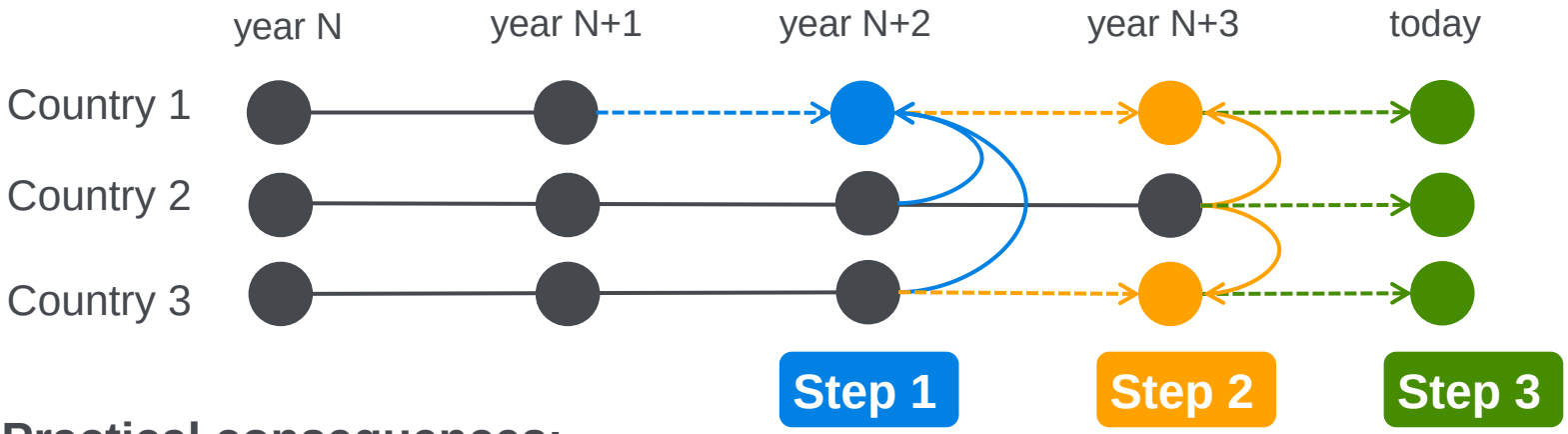


- This diagram shows that the financial strategy suffers from two delays:
  - **Delay 1**, which corresponds to the fact that the **mortality table used is not up to date**, can lead to **inaccurate pricing** because mortality can change during the period
  - **Payment is delayed** after the end of the contract until mortality data release by **Delay 2**, so that the realized mortality at contract's maturity can be used to determine the variable leg.
  - It is then crucial to elaborate solutions to face these difficulties → **Mortality data completion through potentially available data about the remaining countries** (Multi-population models)

Case study: how risky is the future?

(Open) challenge #3: Lag in mortality data // Proposed solution

- Since our aim is to provide the **best estimate of unreleased mortality** for a given country, our idea is **to rely on other countries** for which the information is available
  - This is done by taking advantage of the **joint population modelling framework**
  - The following figure illustrates our **completion algorithm**



- **Practical consequences:**
  - Provide pension plans **up-to-date longevity assumptions** for their specific country
  - Provide international companies **coherent longevity assumptions over several countries**
  - **Refine the pricing of longevity risk transfer solutions**

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Thank you

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