The Use of Guarantees on Contributions in Pension Funds

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Washington DC, January 9, 2012

Global Relevance of DC Pension Systems

- The U.S. has moved to a system where defined contribution (DC) plans play a key role in retirement provision:
  - Corporate defined-benefit (DB) pension plans are disappearing o frozen
  - Public DB pension plans are in acute crisis
  - Social Security is expected to provide minimum pension income.

- Other developed economies are introducing or thinking about introducing DC elements in their public pension systems.

- Pension systems in most developing economies are based on DC plans.

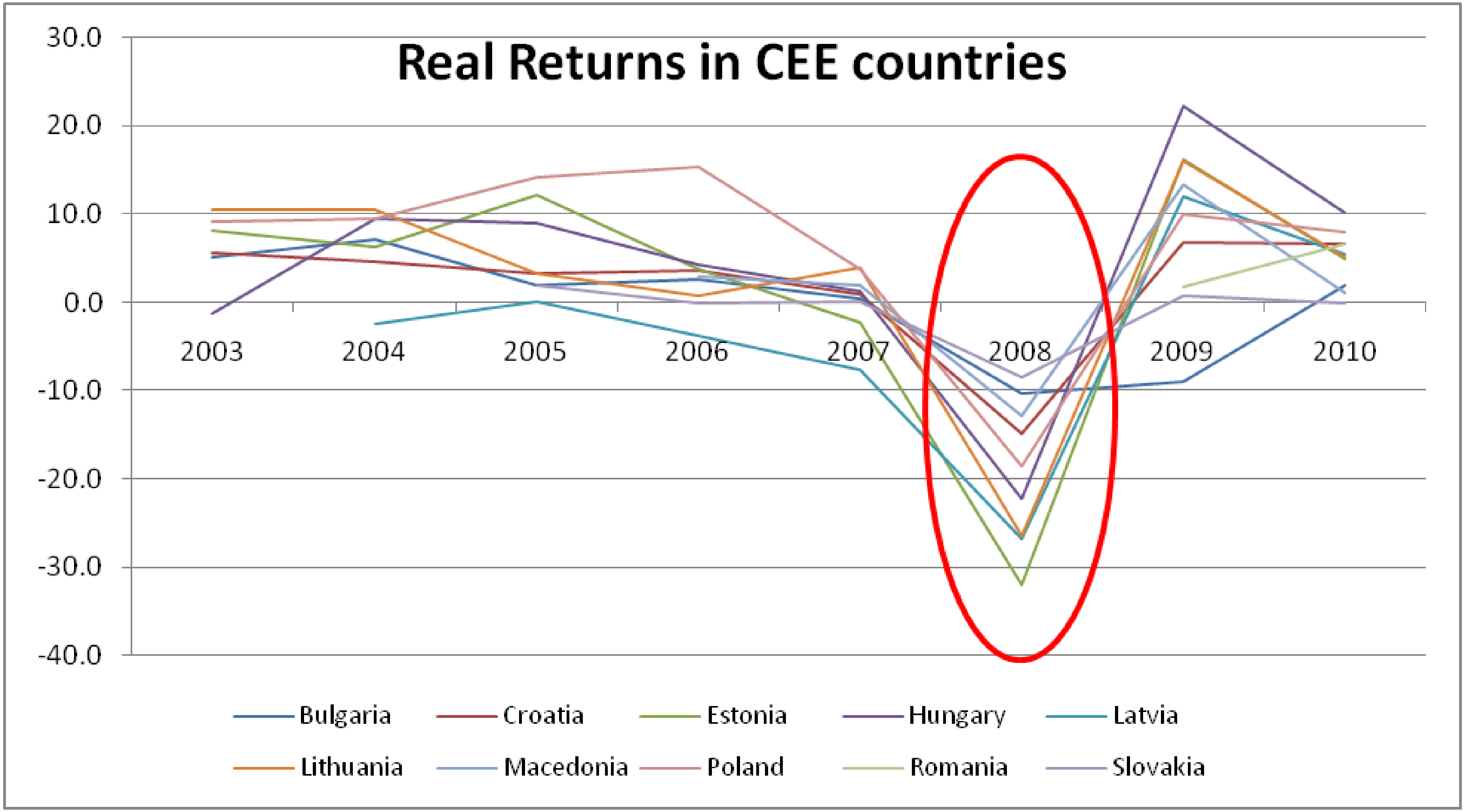
The Meaning of Risk in DC Pension Systems

- DC pension plans typically allow for investment risk during asset accumulation phase, and make this risk exposure decline as participants approach retirement.

- Investment risk works both ways: It increases upside potential of contributions, but it can also result in asset accumulation and thus replacement rates well below expected values.

- At times of large declines in asset values, all plan participants suffer:
  - Those near retirement suffer losses to the extent that their plans still have exposure to investment risk.
  - Young participants might be negatively impacted if the shock to asset values is permanent.
  - Participants with medium retirement horizons are likely to be the most affected: they typically have significant risk exposure which leads to significant losses, and these losses get locked as their life-cycle strategies move out of equities.

Pension Fund Losses during the Crisis



DC Pension Fund Guarantees

- Pension fund losses during the crisis brought back the discussion of guarantees on contributions.

- Pension funds in some emerging economies already have guarantees on contributions:

Guarantees on the Contributions in Selected Emerging Economies

Country	Type of Guarantee	Exercised at	Issued by	Cost to partic.
Kazakhstan	Real value of contributions	Retirement age	Government	Free
Hungary	Real value of contributions	Retirement age	Government	Free
Romania	Nominal value of cont.	Subject to interpr.	PFMCs	Free
Russia	Nominal value of cont.	Subject to interpr.	PFMCs	Free
Slovakia	Nominal value of cont.	Biannually	PFMCs	Free
Colombia	Nominal value of cont.	Retirement age	Specialized Agency	0.15% AUM

This paper

- Guarantees are typically on the value of the contributions (nominal or real) and are provided free of charge to pension plan participants (i.e., taxpayers assume the cost).

- This paper examines guarantees on DC plans.

- Price guarantees on contributions:
  - How much more expensive are real guarantees than nominal guarantees?
  - How much more expensive are guarantees on plans with significant equity exposure than guarantees on more conservative plans?

This paper

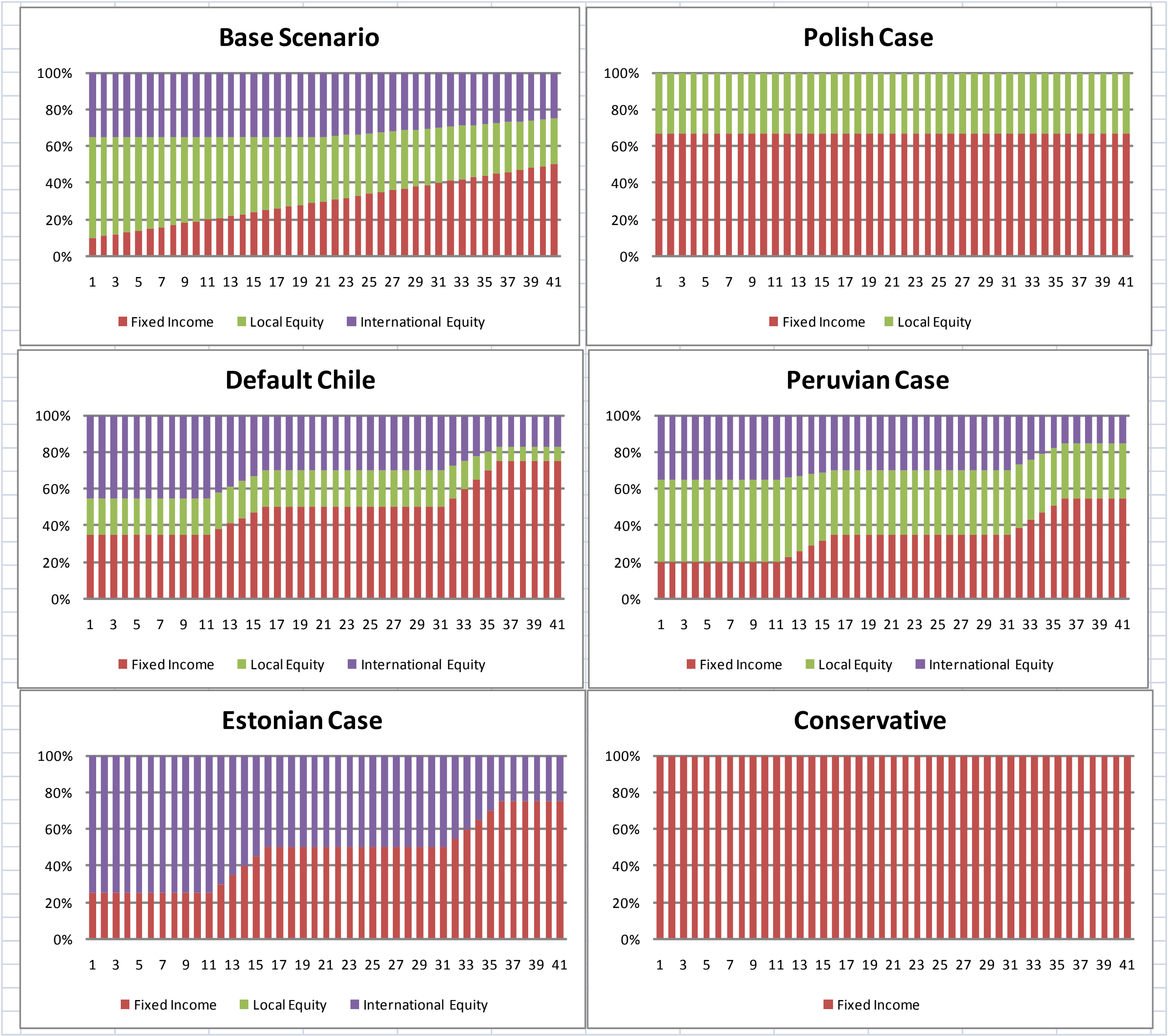
- Examine impact on asset accumulation and replacement rates:
  - What impact do these guarantees have on expected asset accumulation and replacement rates?
  - If these guarantees are exercised, what kind of minimum asset accumulation and replacement rates do they provide?

- Implementation:
  - How to hedge guarantees?
  - Who should pay for them? Intergenerational risk transfers

Guarantees as a Put Option

- A guarantee on value of contributions is a portfolio of put options on the portfolio underlying the pension fund investment strategy.
- Each option differs from the others in its time to expiration.
- Example:
  - Guarantee on contribution of $1 at age 35 with retirement age at age 65 is a guarantee that 30 years from now the participant will get at least $1 (if the guarantee is nominal) or at least $1 plus inflation (if the guarantee is real).
- At retirement, participant holds as many guarantees as years he has contributed to the plan.

Pricing the Guarantees: Fund Strategies



Pricing the Guarantees

- We price three guarantees:
  - Guarantee on nominal value of contributions
  - Guarantee on real value of contributions
  - Guarantee on real value of contributions plus 1% p.a.

- Note that:
  - Nominal guarantees are more valuable than real guarantees in deflationary environments, because their real value increases in those scenarios.
  - Real guarantees are more valuable in inflationary environments.

Pricing the Guarantees

- We price the guarantees (or put options) on each of these funds through standard numerical methods:
  - Underlying investment strategies typically change asset allocation over working life of plan participant
  - We want to allow for stochastic interest rates
  - We abstract from time-varying asset return volatility and correlations.

- Assumptions:
  - Bond allocation is on an inflation indexed bond whose maturity equals time to retirement
  - Local equity is the Chilean stock market
  - Interest rates and inflation are also for Chile

Parameter Assumptions

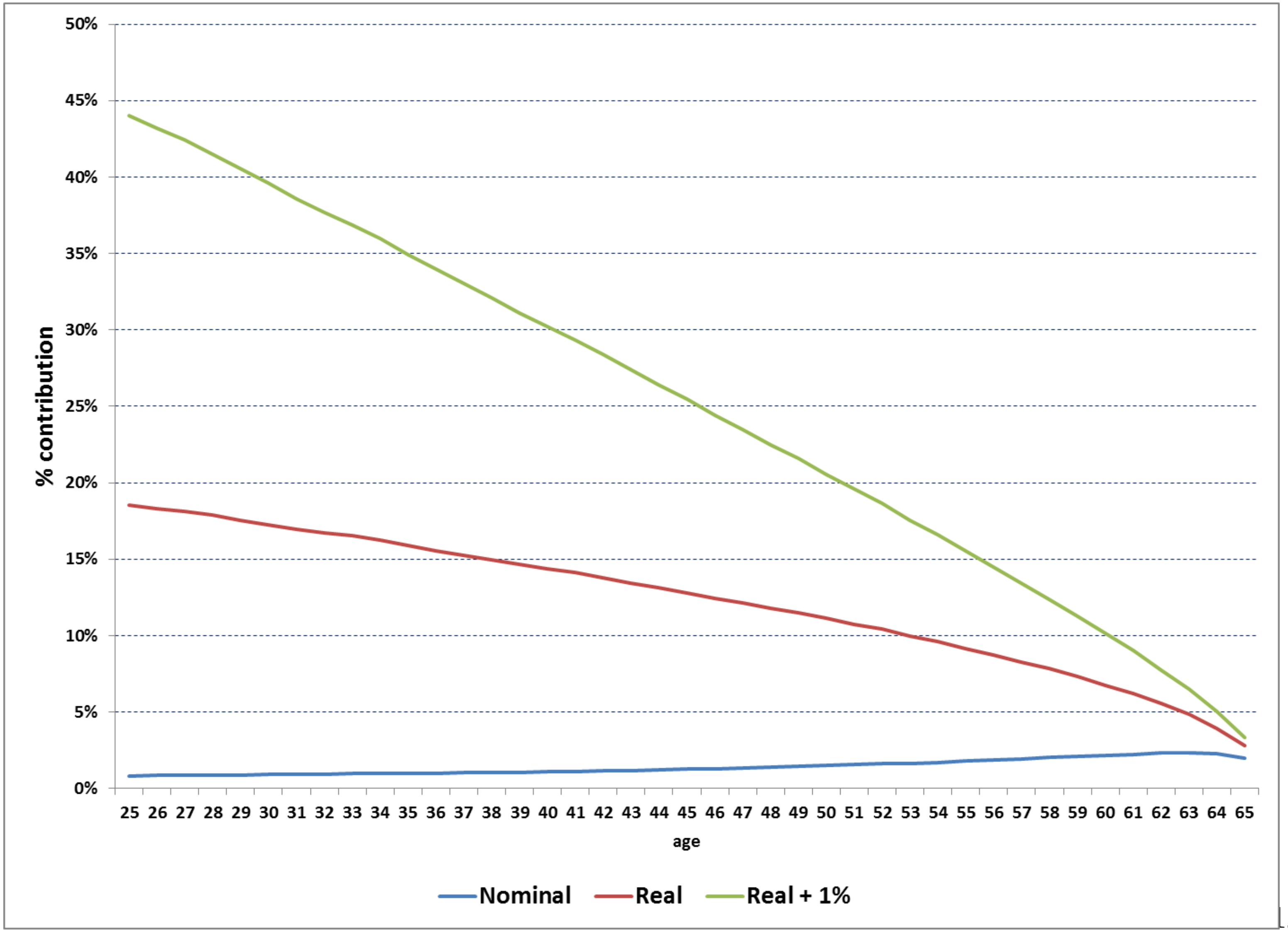
Parameters

	Local equity (real)	World equity (real)	Local real interest rate	Inflation
μ (% p.a.)	7.5	6.5	1.0	3.0
σ (% p.a.)	23.1	16.7	1.4	1.9
AR(1)	..	..	..	0.439
Velocity	..	..	0.383	..

- We assume a 38.3% correlation between local equity and global equity returns, and zero for all other correlations.

- We conduct 10,000 simulations for each strategy, evaluate the payoff on the strategy with and without the guarantee, and price the guarantee via risk neutral methods.

Value of Guarantees in Base Case (% of contributions)



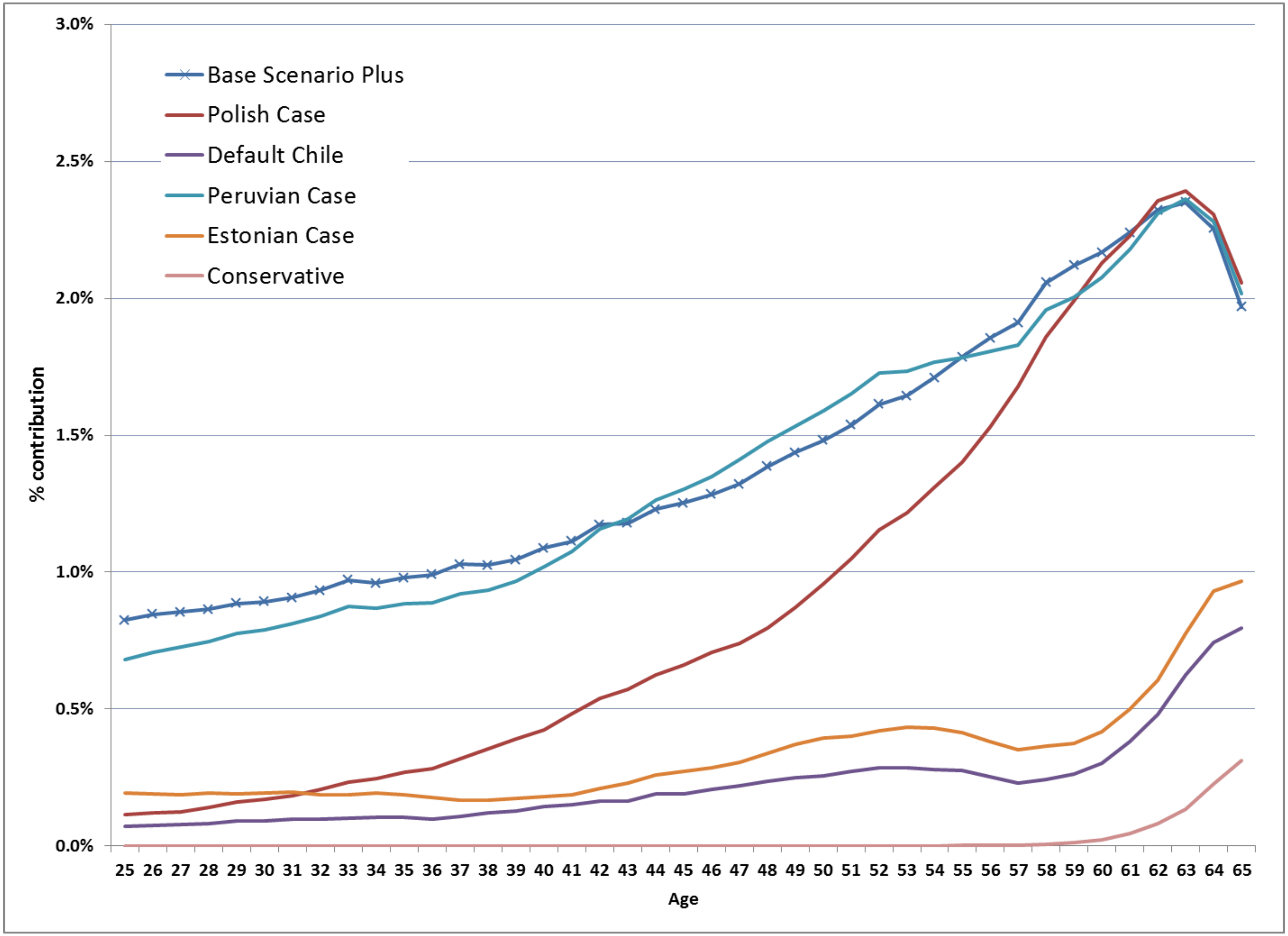
Value of Guarantees in Base Case

- Holding inflation and interest rate constant, value of guarantees generally declines as retirement approach because fraction of assets invested in equities declines.

- At long horizons, real guarantee is much more expensive than nominal guarantee:
  - Inflation process implies that inflation trends upwards. Thus real value of nominal guarantees declines over time.
  - Controlling for asset allocation, cost of nominal guarantee increases over time as retirement approaches.

- At very short horizons, nominal guarantees could be more expensive than real guarantees:
  - There is some risk of deflation which is greatest at short horizons, and underlying assets are all real

Cost of Nominal Guarantees for Different Scenarios

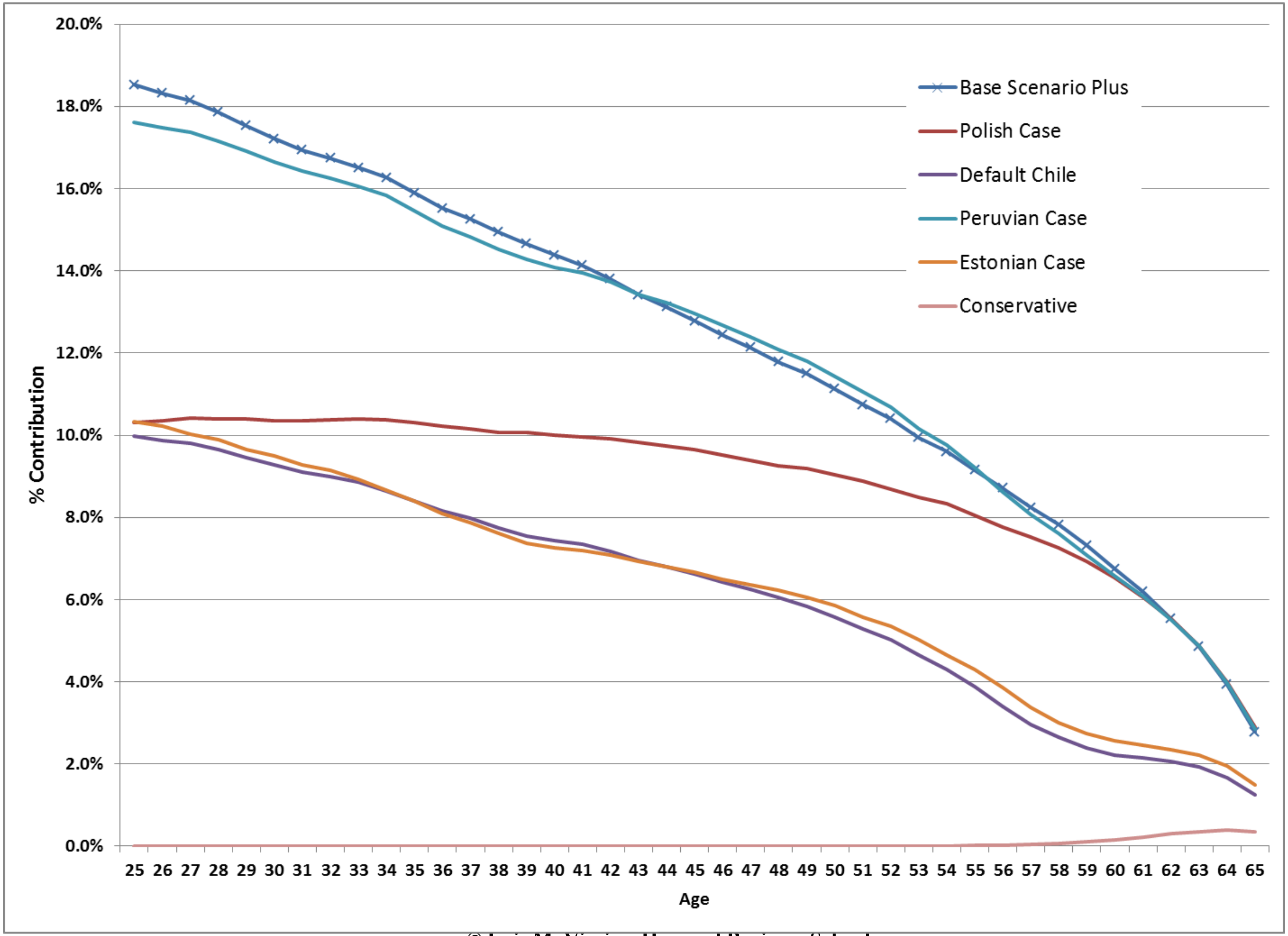


Cost of Nominal Guarantees for Different Scenarios

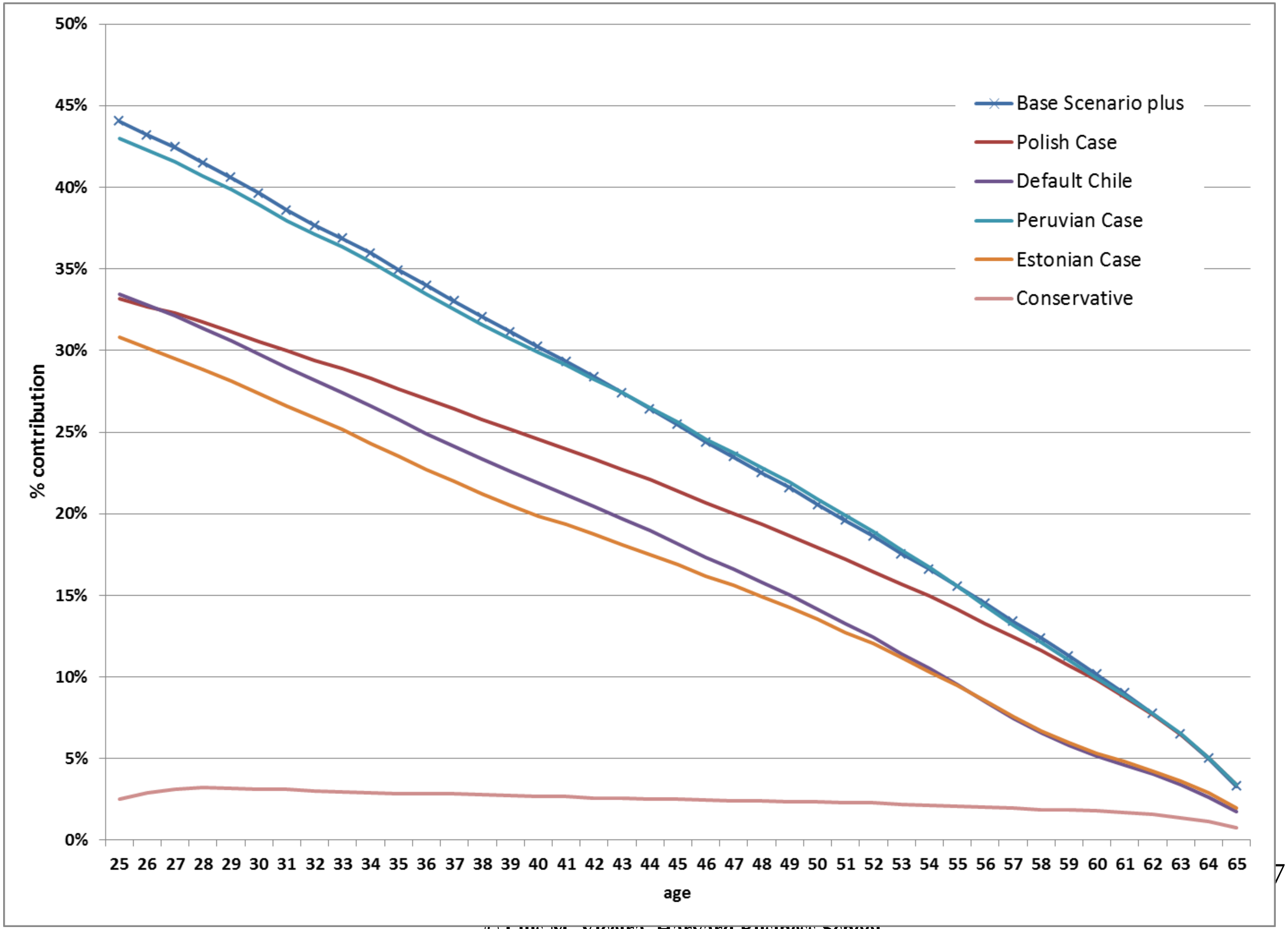
- Guarantees on more aggressive strategies are more expensive than conservative strategies.
  - The conservative case is the least expensive scenario, but its cost increases over time because the underlying bonds are inflation-indexed and do not protect against risk of deflation.

- Controlling for equity/bond split, guarantees on funds that invest more in local equity are more expensive:
  - Base case and Peruvian case are twice as expensive as Chilean case and Estonian case despite having similar bond/equity allocations.

Cost of Real Guarantees for Different Scenarios



Cost of Guarantees of Real + 1%



Implementation

- The guarantee can be implemented buying enough zero-coupon bonds (nominal or inflation-indexed) paying amount of contribution at retirement age.
- Bond allocation of underlying portfolio strategy in the fund may already cover part or all of the investment in zero-coupon bonds needed.
- Calculated cost of the guarantees is simply how much additional investment in zero-coupon bonds would be necessary to ensure recovery of contribution at retirement.

Implementation

- This suggests tailoring bond allocation in pension fund to guarantee recovery of contribution at retirement:
  - Invest in enough zero-coupon bonds (nominal or inflation-indexed) paying the amount of contribution at retirement age.
  - Invest the rest in equities, preferably an internationally-diversified portfolio of equities.

- Alternatively, government might take care of bond allocation, and leave equity allocation to pension fund managers.

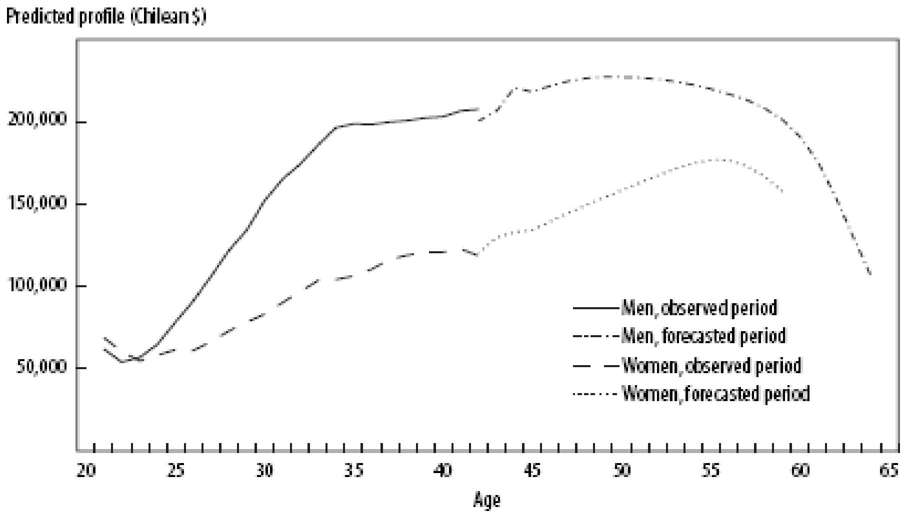
- Overall resulting asset allocation may or may not look like a life-cycle fund, depending on type of guarantee and level of interest rates.

Implementation

- The system could be self-contained to the extent that younger generations sell these bonds to older generations.
- But they would have to invest the proceeds from those sales into underlying bonds to hedge their exposure.
- From whom should they buy those bonds?
- Ultimately, guarantees will be as good as the credit worthiness of the underlying bonds used to hedge them.

Pension Results

- To compute pension results with and without guarantees, we follow Viceira (2010) to compute labor earnings and pension contributions:
  - Labor earnings follow inverted U-shape over working life, subject to permanent and transitory shocks.
  - Contributions are 10% of labor earnings.
  - Deterministic component of labor earnings taken from Bernstein, Larrain, and Pino (2006):



Pension Results

- Pension results at retirement age have two sources of uncertainty:
  - Investment uncertainty: return on equity returns, bond returns, interest rates, and inflation.
  - Labor income uncertainty

Standard Deviation of Asset Accumulation at Retirement Age
(millions of pesos)

	Base				Conservative			
	No Guarantee	Nominal	Real	Real +1%	No Guarantee	Nominal	Real	Real +1%
Deterministic Income, Constant Rate	8.7	8.6	7.4		0.0	0.0	0.0	
Deterministic Income, Stochastic Rate	8.8	8.7	7.3		0.2	0.2	0.2	
Stochastic Income, Constant Rate	13.9	13.8	12.2	10.0	5.6	5.6	5.6	5.7
Stochastic Income, Stochastic Rate	13.9	13.8	13.6	9.7	5.6	5.6	5.6	5.6

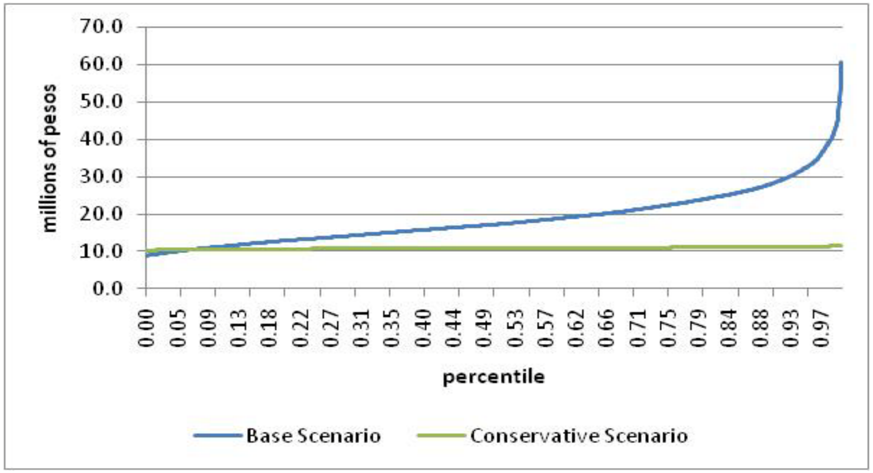
- We will focus on pension results along expected contribution path and with a real guarantee.

Impact of Guarantees on Pension Results

Comparison of Asset Accumulation on Base and Conservative Scenarios[1]
(millions of pesos)

	No Guarantees		Real	
	Base	**Conservative**	**Base**	**Conservative**
Average	21.7	10.9	18.8	10.9
SD	8.8	0.2	7.3	0.2
Percentile 1	8.7	10.3	9.1	10.3
Percentile 50	19.8	10.9	17.2	10.9
Percentile 90	32.9	11.2	28.2	11.2

[1] It assumes deterministic income, stochastic rate



Impact of Guarantees on Pension Results

Replacement Rate for Different Scenarios[1]
(as a percentage of last income)

	Average		Percentile 1	
	No Guarantee	**Real**	**No Guarantee**	**Real**
Base	104%	90%	38%	38%
Conservative	52%	52%	35%	35%
Chile Default	81%	75%	40%	39%
Estonian	85%	79%	37%	38%
Peruvian	100%	87%	37%	38%
Polish	74%	68%	32%	35%

[1] Deterministic Income, stochastic rate

Impact of Guarantees on Pension Results

- Generally, real guarantee kicks in at approximately 1% of distribution of pension outcomes.
  - That is, sum of contributions adjusted for inflation is equal to percentile 1 of the distribution of accumulated assets.
- Real guarantee buys an annuity equal to at least 32%-40% of salary in last year of working life, and ensures an average replacement ratio of 68%-90%, versus 52% in a conservative strategy.
  - Guarantee is calculated taking into account interest rates generated by our model and actuarial tables for Chile.
- Guarantee assumes 10% contribution along expected path of labor earnings over working life, i.e., it is for a typical pension plan participant.
  - When we allow for labor income uncertainty, we also introduce dispersion in pension outcomes.

Pension Results with Guarantees

Assets at Retirement Age with Guarantees on the Real Value of Contributions (compared to Base Scenario)

	Base	Conservative	Chile Default	Estonian	Peruvian	Polish
Deterministic Income, Constant Rate						
Average	100%	57%	83%	88%	96%	76%
SD	100%	0%	52%	70%	95%	59%
Percentile 1	100%	121%	105%	102%	99%	98%
Percentile 50	100%	62%	88%	90%	97%	77%
Percentile 90	100%	38%	73%	81%	96%	70%
Deterministic Income Stochastic Rate						
Average	100%	58%	83%	88%	96%	76%
SD	100%	3%	52%	71%	95%	59%
Percentile 1	100%	113%	104%	101%	99%	98%
Percentile 50	100%	63%	88%	91%	96%	78%
Percentile 90	100%	40%	74%	82%	96%	71%

Conclusions

- DC pension results in the wake of the global financial and economic crisis have triggered discussion around minimum guarantees in pension funds.
- Current and proposed guarantees call for guaranteeing either the nominal or the real value of pension contributions.
- We show that the cost of such guarantees as a fraction of contributions is relatively small for nominal guarantees (1%-2%), but more significant for real guarantees (as high as 20% of contributions) at long horizons .
- The value of nominal and real guarantees is about the same at short horizons (1%-3%)

Conclusions

- Real guarantees ensure minimum replacement ratios in the order of 32%-35%.
- At the same time, the underlying risky portfolio strategies provide significantly larger average replacement ratios than conservative strategies.
- It is important to think carefully not only about the cost of providing these guarantees, but also about their implementation.
- Who will make good on these guarantees?
- Even if these guarantees are hedged via investments in appropriately designed bond portfolios, they are still subject to the default risk on those portfolios.

Supplementary Slides

Stochastic Interest Rate

- The model assumes that interest rates follows the short term dynamics of the Vasicek model;

$$r_{t+1} = r_t + \gamma(\bar{r} - r_t)\Delta t + \sigma_r \sqrt{\Delta t}\varepsilon_{3t}$$

- The analytic expression of a zero coupon bond with T years of maturity (B(t,T))is given by:
- $$B(t,T) = \exp\left(-A(t,T)r_t + D(t,T)\right)$$

$$A(t,T) = \frac{1 - \exp\left(-\gamma(T-t)\right)}{\gamma}$$

$$D(t,T) = \left(\bar{r} - \frac{\sigma_r^2}{2\gamma}\right)\left(A(t,T) - (T-t)\right) - \frac{\sigma_r A(t,T)^2}{4\gamma}$$

- We feed the Vasicec formula with the parameters calculated by Molinare (2002) for Chile $\gamma = 0.3831$ $\sigma_r = 3.6305\%$ $\bar{r} = 3\%$

Labor Earnings

- Life-cycle labor income:

$$\ln w_t = f(t) + v_t + \varepsilon_t,$$

$$v_t = v_{t-1} + u_t$$

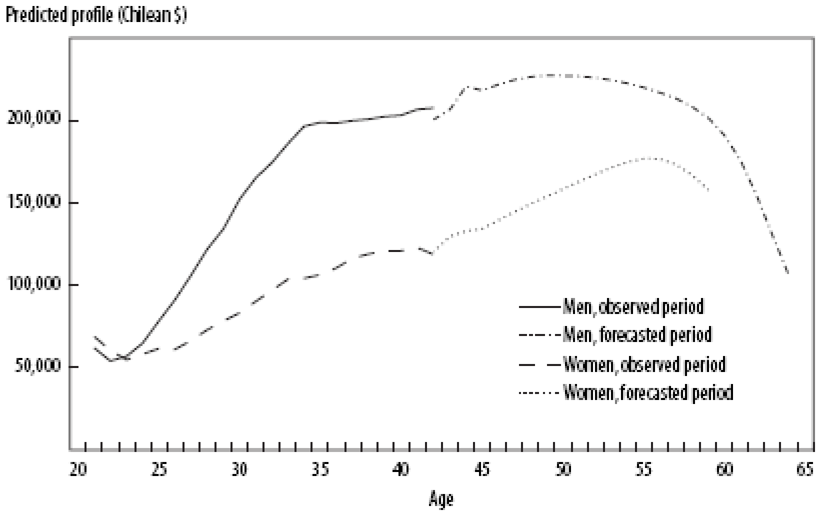
  - f(t) is a deterministic age-dependent component of earnings
  - permanent shock u and transitory shock ε are uncorrelated and normally distributed.

- Participant joins the labor force (and starts contributing to the plan) at age 25, and retires at age 65.

- Contribution rate is 10% of monthly salary.

Labor Earnings

- Deterministic component of labor earnings taken from Bernstein, Larrain, and Pino (2006):



- Labor income uncertainty taken from US estimates:
  - Standard deviation of shocks to permanent income (v_t) = 13.89%
  - Standard deviation of shocks to permanent income (ε_t) = 10.95%

Table 9	Key Triggering Points on Asset Accumulation[1]	
	Guarantees on real contributions trigger at	Breakeven with average of conservative strat.
Base	0.10%	8.5%
Chile	<0.01%	6.4%
Estonian	<0.01%	9.3%
Peruvian	0.10%	10.0%
Polish	0.70%	23.8%
[1] Deterministic income, stochsatic rate		

Conclusions

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Generation funds with guarantees

Introduction

- The Product – short description
- Pricing of Guarantees
- Finding the optimal lifecycle asset allocation in a product with a guarantee
- Risk control

The product

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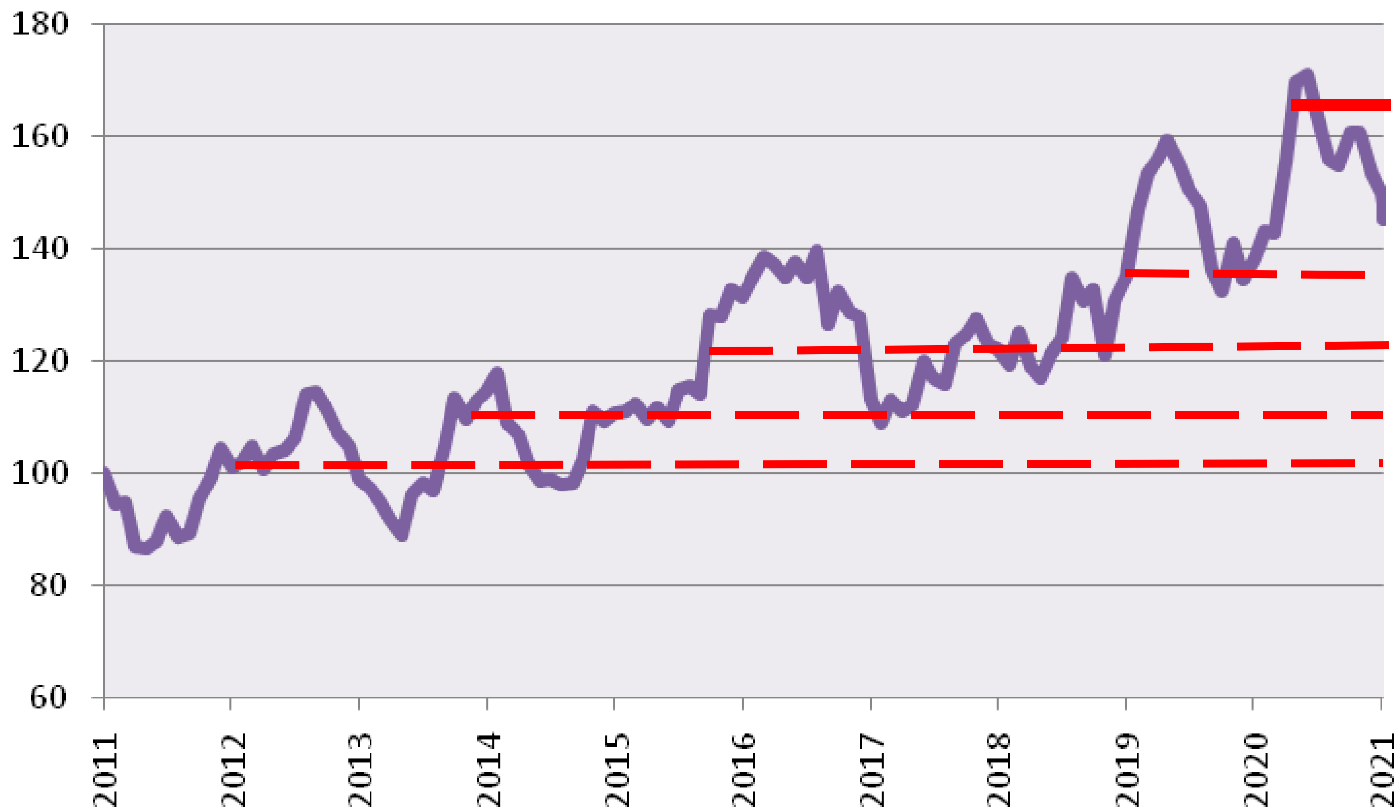
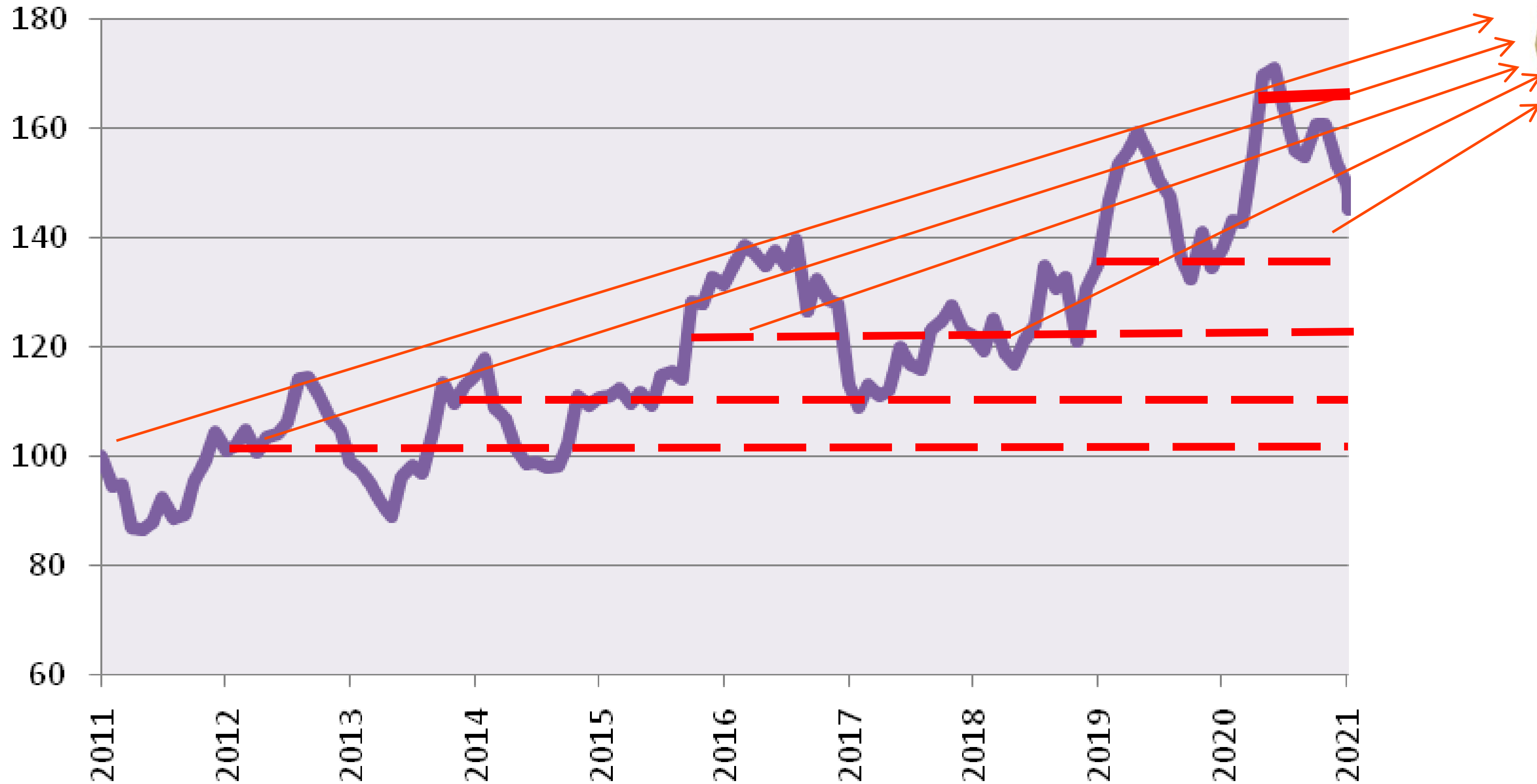
- **Yearly lock-in guarantee:** 100% of portfolio value is locked in on the 31 of Dec. every year



The guarantee fee

- A fee is charged for the guarantee



Company covers any shortfall

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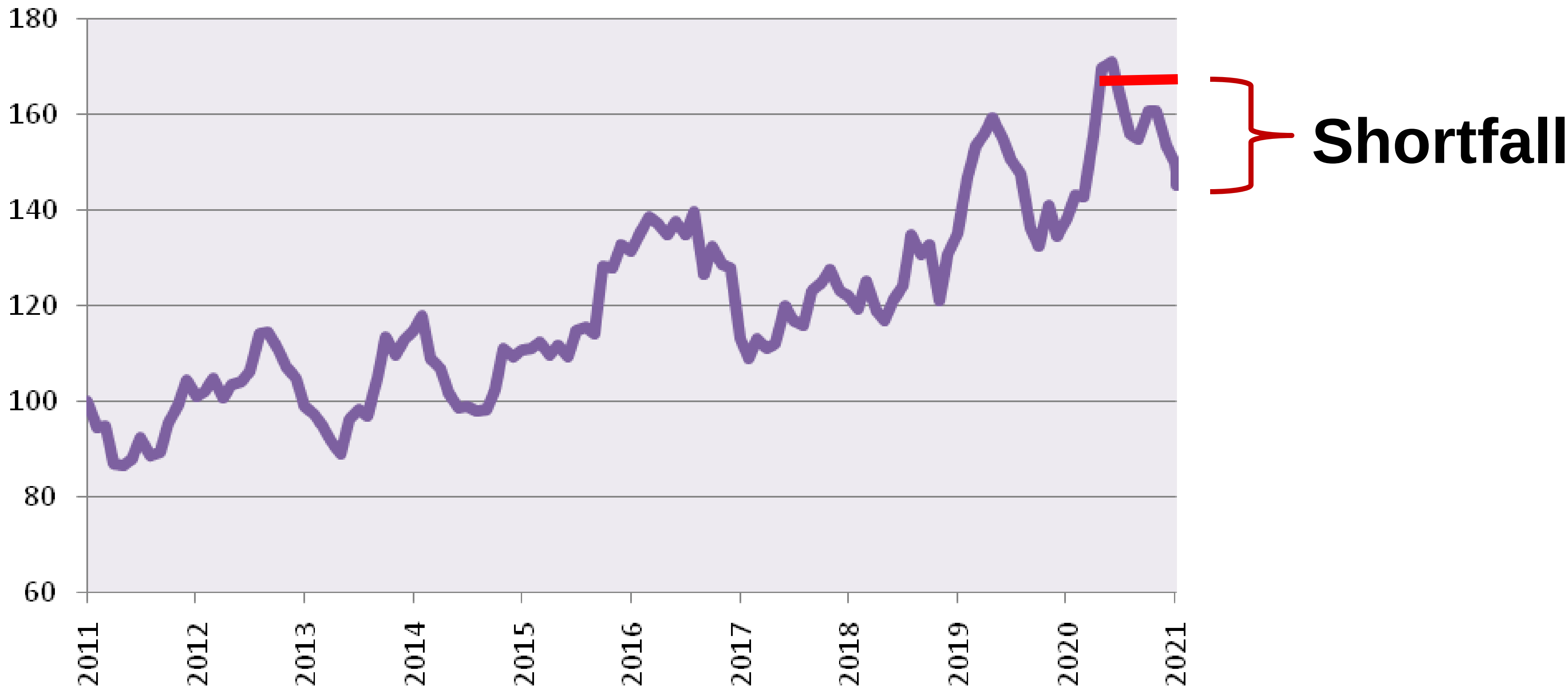
- At retirement, company covers any shortfall between portfolio value and highest guarantee value.



Time varying Asset allocation

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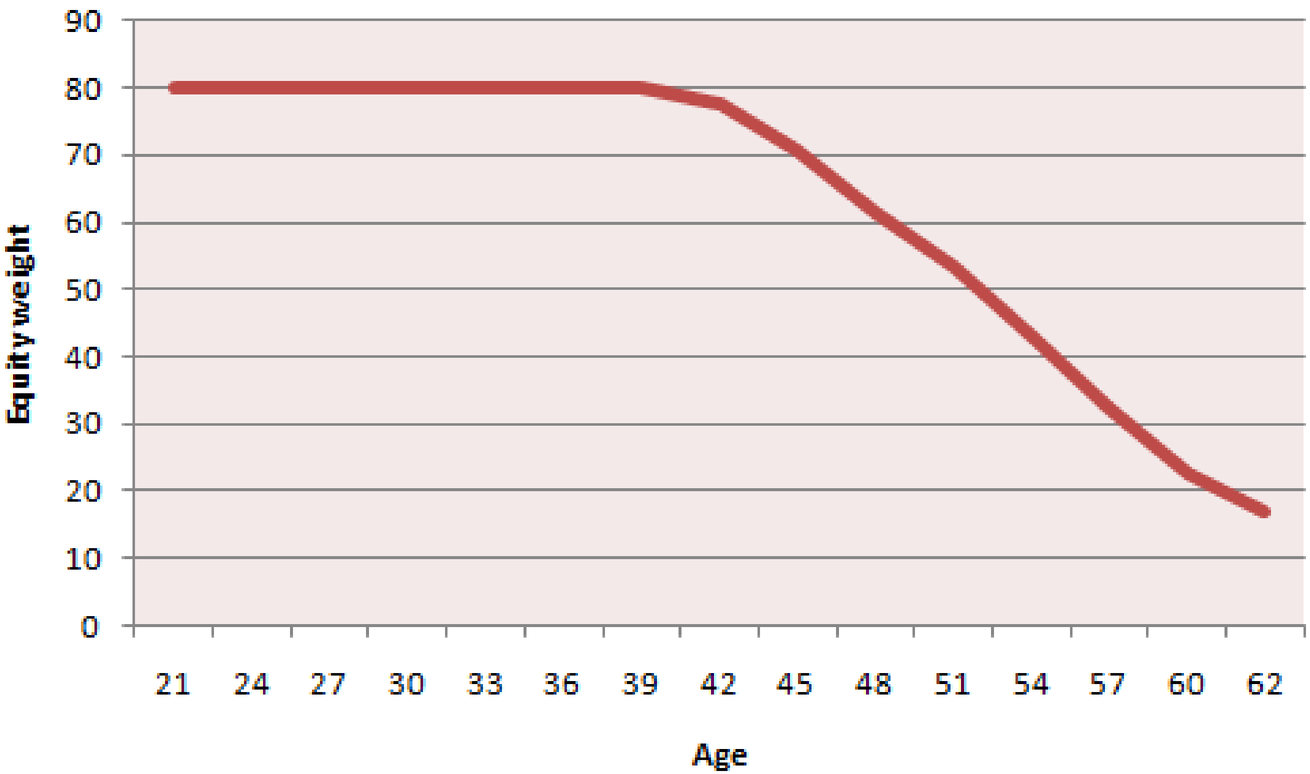
- Each individual gets allocation according to his or her age.



Pricing the guarantee

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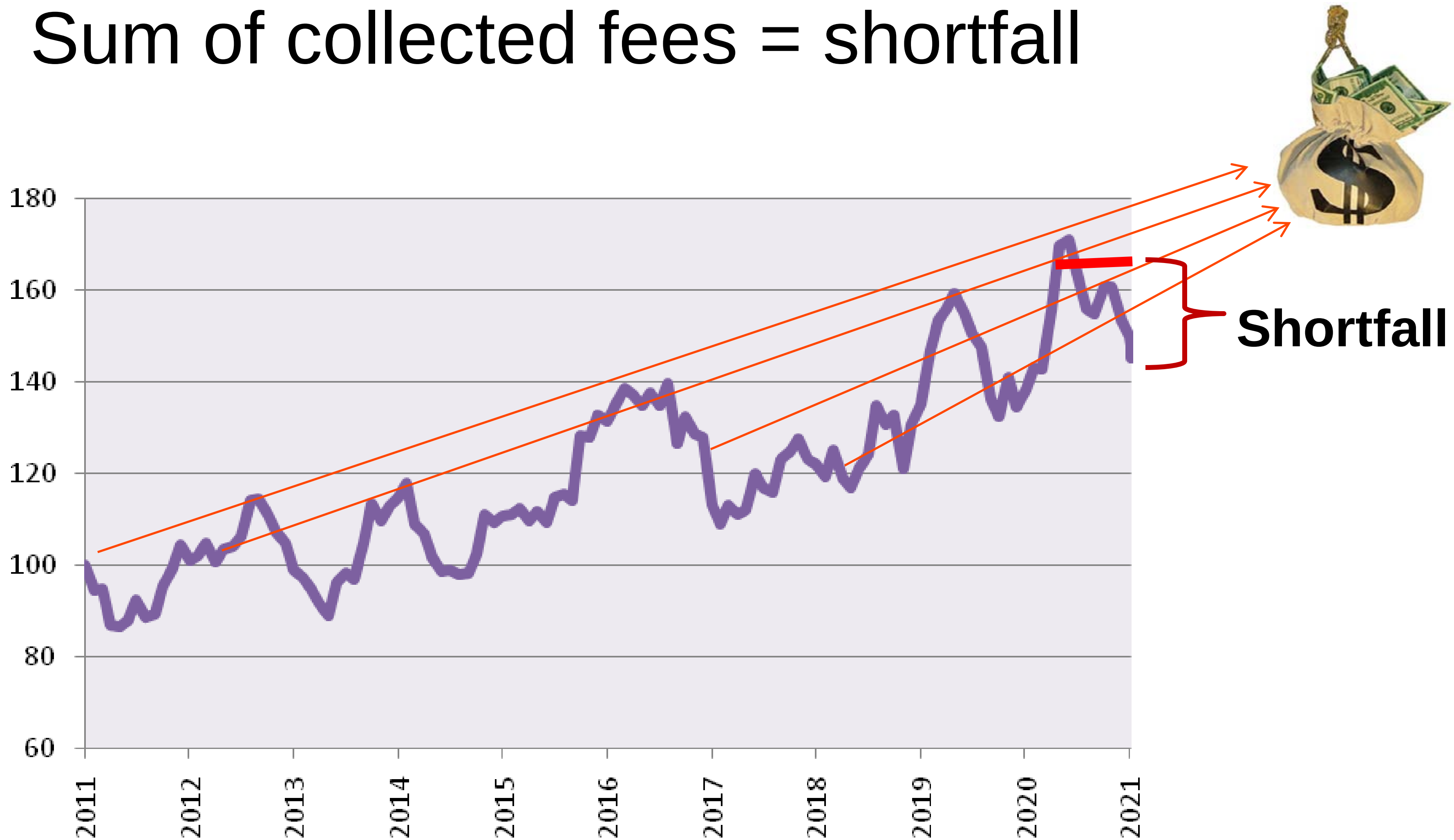
Sum of collected fees = shortfall



Pricing the guarantee

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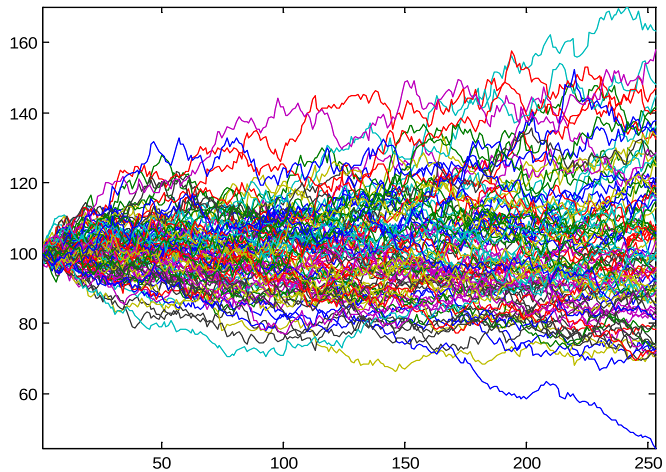
By Monte Carlo simulation

1. Simulate a large number of different scenarios for underlying assets (e.g. stocks and bonds)
2. For each scenario: Simulate the product and calculate:
   - Collected fees
   - Shortfall
3. Average over all scenarios and find the fee that makes:

Average(Collected fees) = Average(Shortfall)

Pricing of the guarantee



Guarantee Fee

Simulation Model

Collected fees
Shortfall

- Use additional information from the distribution in the pricing

Calculating the allocation curve

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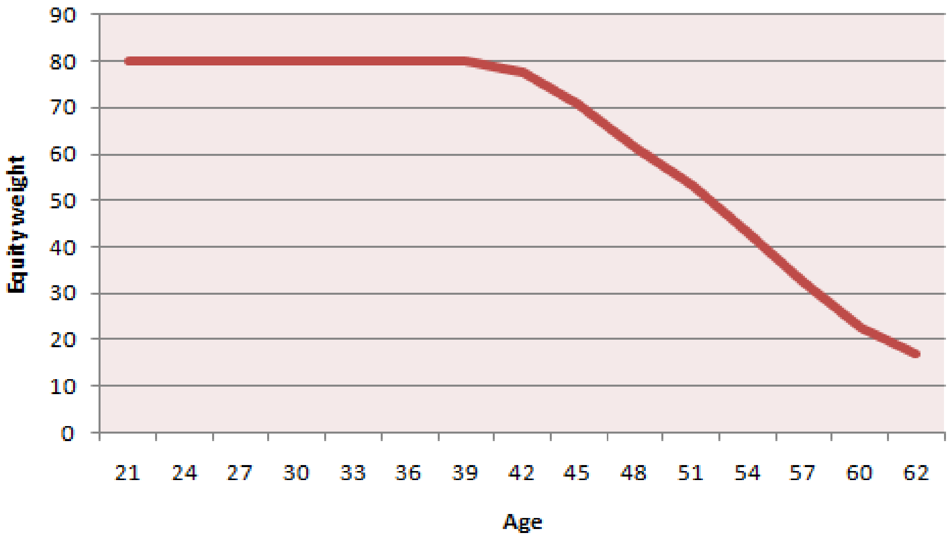

- Shape of the curve determines potential return and risk
- It also affects the price of the guarantee.

Finding the ”optimal” allocation curve?

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I.e. an allocation curve that gives:

- Good return potential
- Limited downside
- Cheap guarantee

- Expected return
- Drawdown, LPM
- Guarantee Price

1. Formulate your goals as objective functions

2. Use multiobjective optimization techniques to find the ”optimal” allocation

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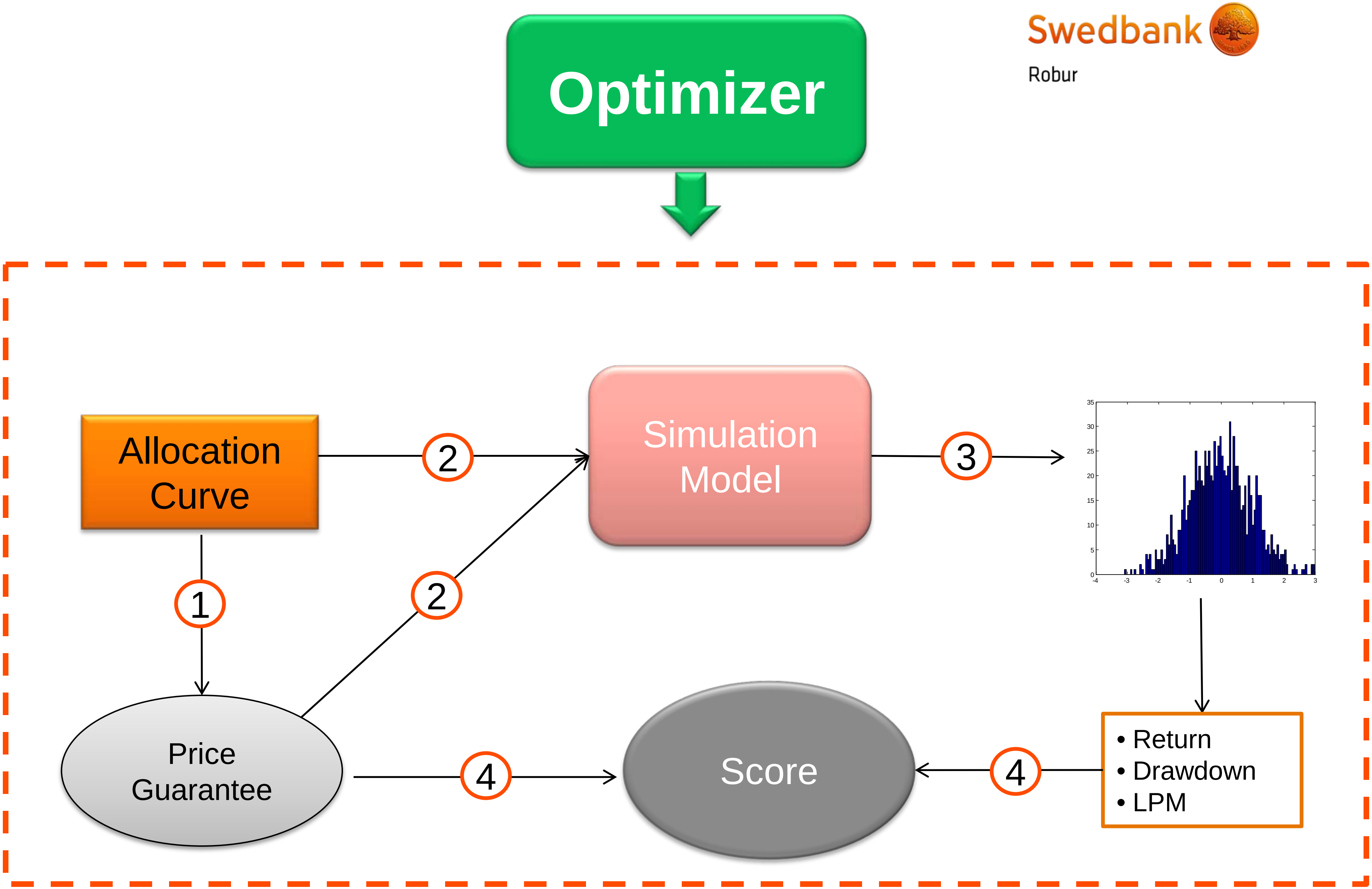
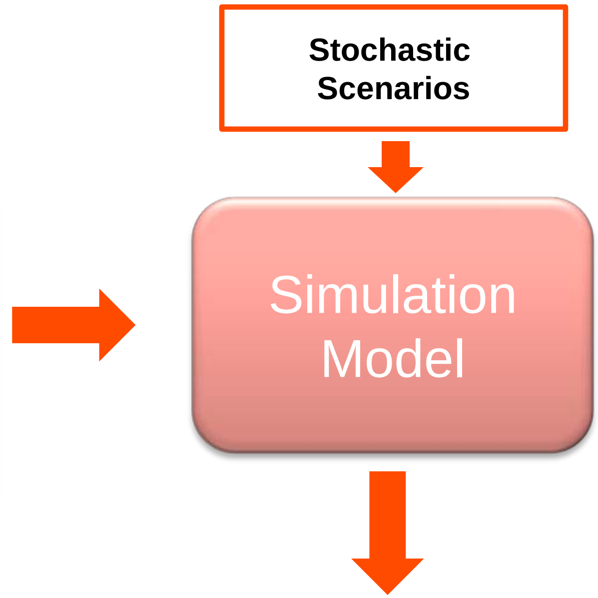


Risk control

Data, all individuals

Individual	Portfolio Value	Current Guarantee	Time to retirement	...
1	100	110	23	...
2	110	90	12	...
3	80	85	1	...
...	...	...	...	...



- Risks
- Fair fee
- Scenario analyses

- This is also important in order to meet regulatory demands, e.g. Solvency II

Conclusion

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- Important to price the guarantee properly
- Multiobjective optimization to find the optimal lifecycle asset allocation
- Important to monitor the risks

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The Role of Guarantees in Second Pillars: Case of Slovakia

5th Contractual Savings Conference

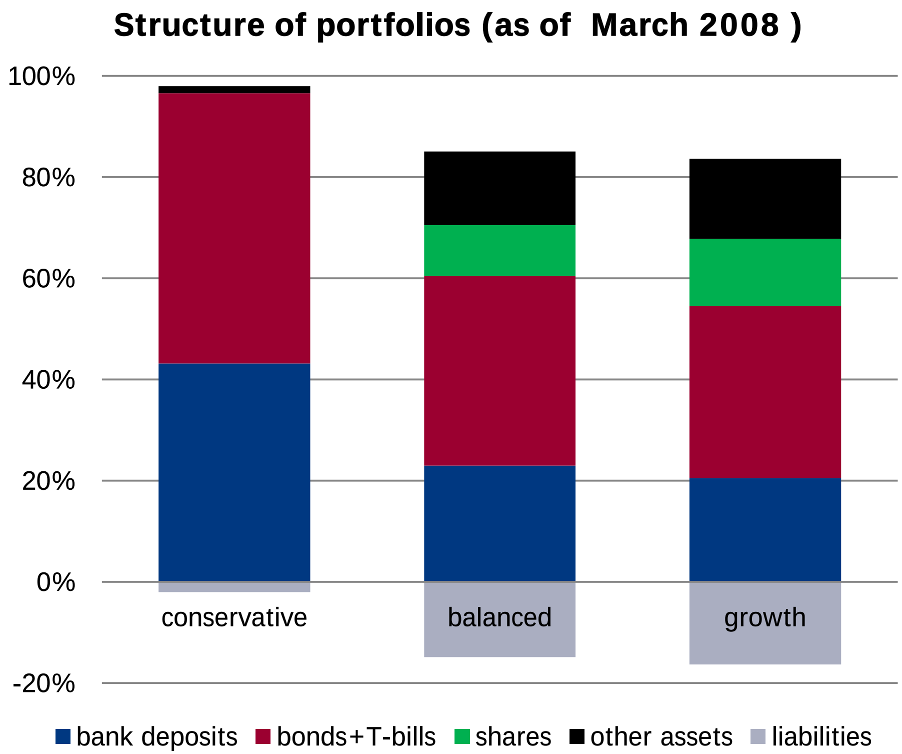
2nd pillar in Slovakia

- January 2005: mandatory, DC, multiportfolio system with individual accounts, carved out of public PAYG system (contributions 50:50)
- As from June 2006 automatic enrollment
- Coverage: 70% of working population
- Success story!

2005: Guarantees

- Internal benchmarks: comparison of yields of the same type portfolios with an obligation of the management company to pay money to the fund from its own pockets

- Market response
  - Herding behaviour
  - Low-risk portfolios



Reg. limits	0%	50%	70%
Reality	0%	14%	20%

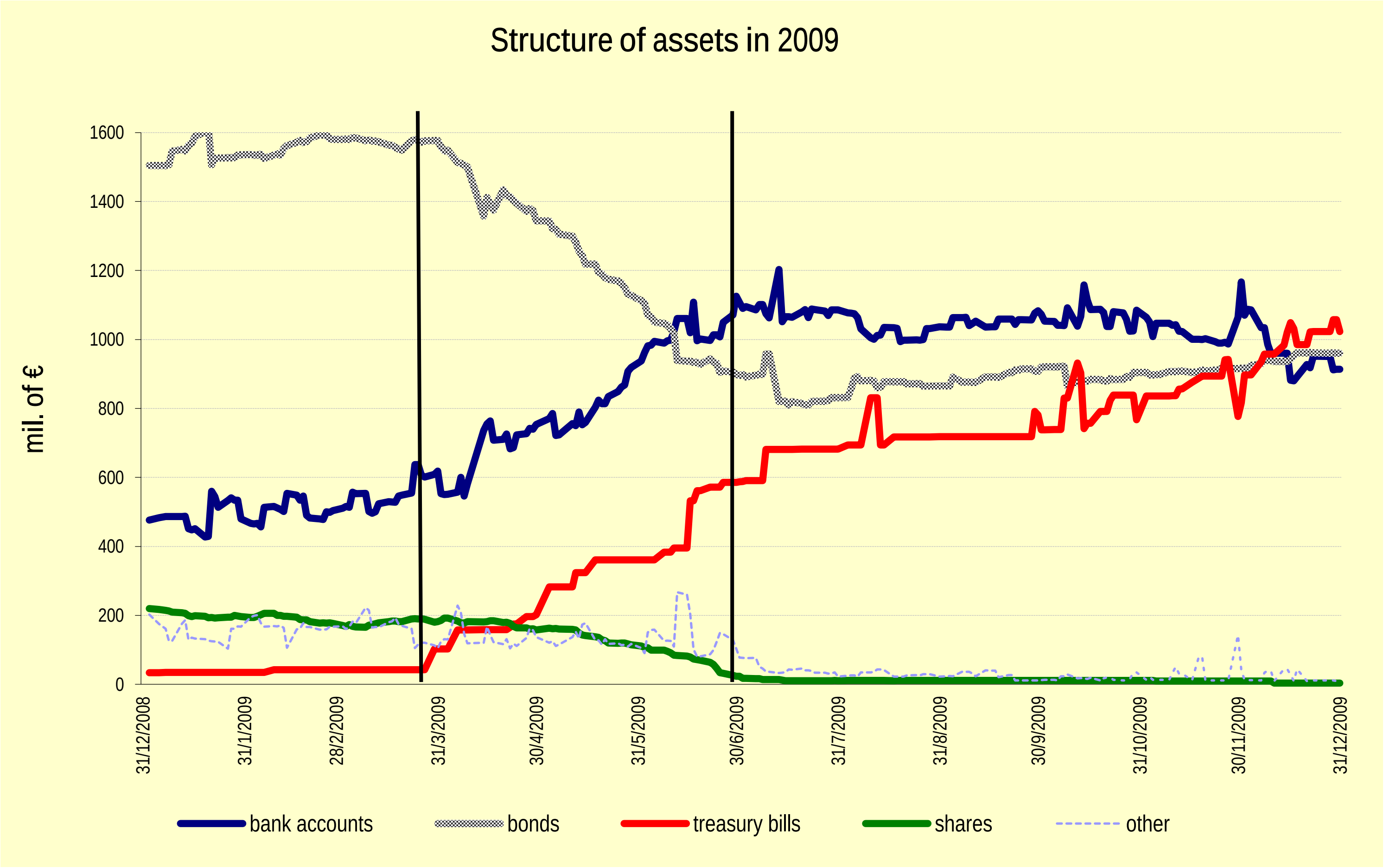
2009: changes of the guarantees

External benchmarks +crisis:

a) conservative portfolio
- Average yield to remain stable **over 6 months period**
- Underperfomance: Management company to transfer money from its own pockets to the pension fund
- Sanctions

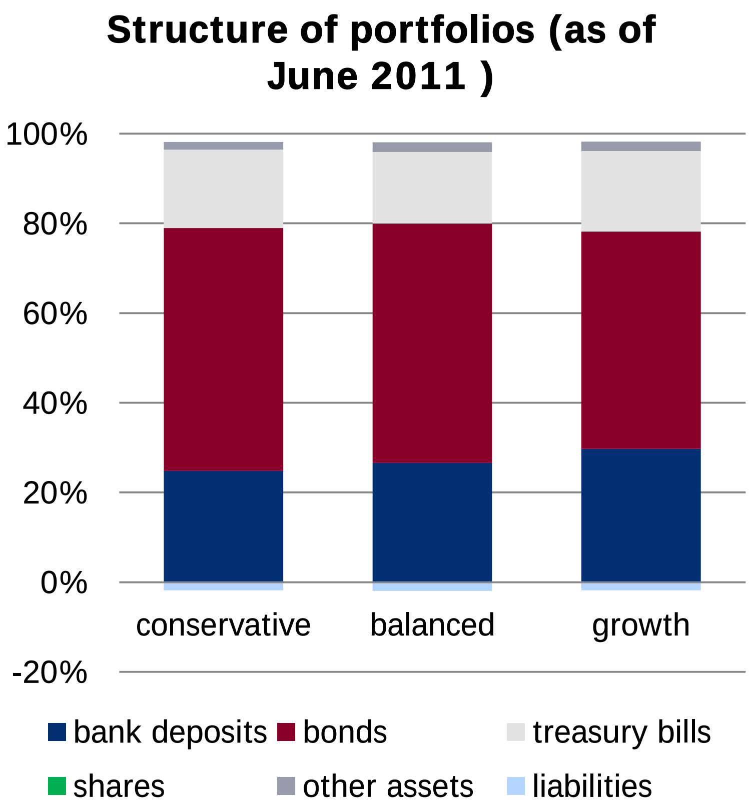
b) balanced and growth portfolio
- The asset structure to match the benchmark compiled by management companies and disclosed in prospectus
- No sanctions

Market response

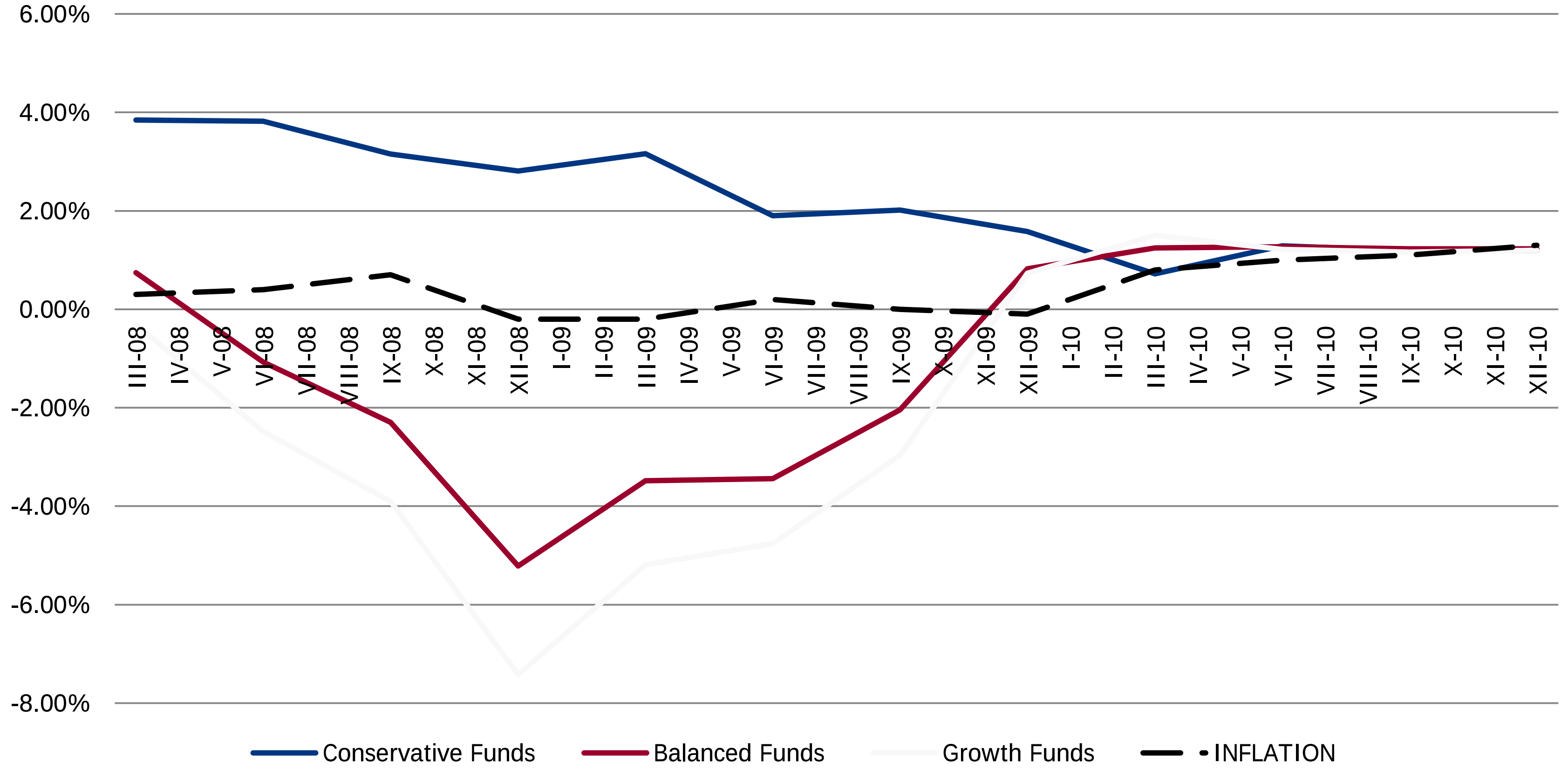


Market response

- Market response
  - Sale of shares
  - Duration of portfolio<1 y



2nd pillar performance



2012: further changes of the guarantees

Guarantees

- To remain only in conservative portfolios
- Comparing the average yields over the 5 years period
- Underperformance: Management company to transfer money from its own pockets to the pension fund

Thank you for your attention

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