IAALS Coloquium Barcelona 2017

Collective Defined Contribution Plans - Backtesting based on German capital market data 1955 - 2017

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DB / CD / ICD /CDC Pension Plans

Definded Benefit (DB): The pension benefits depend on years of service and/or final salary.

- The contributions are determined by the benefits.
- Employer bears capital market/ longevity risk

Defined Contribution (DC): The pension benefits depend on the contributions/ investment returns/ surviving probabilities.

- The benefits are determined by the contributions.
- Employee bears capital market/ longevity risk

DB / CD / ICD /CDC Pension Plans

Individual Defined Contribution (IDC): The contributions are credited to an individual account

- The indiv. benefits are determined by the indiv. contributions.
- Each Employee bears capital market/ longevity risk individually.

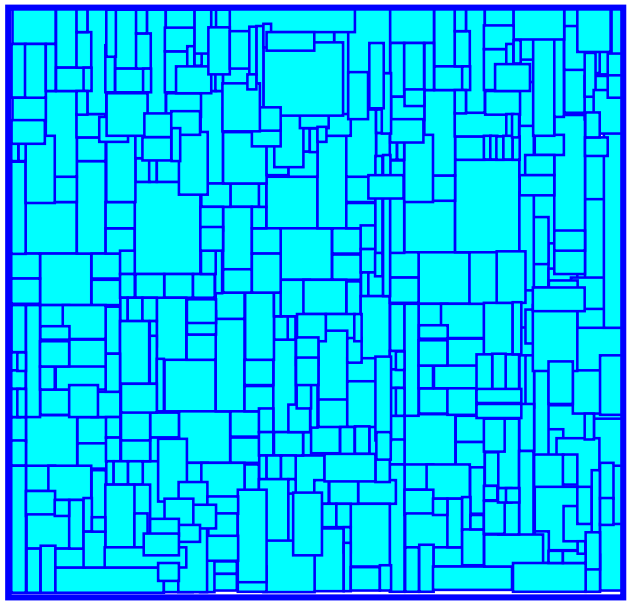
Collective Defined Contribution (CDC): The pension benefits depend on the contributions/ investment returns/ surviving probabilities.

- The benefits are determined by the contributions.
- **Employees share capital market/ longevity risk collectively.**

Collective Saving: Model and Data

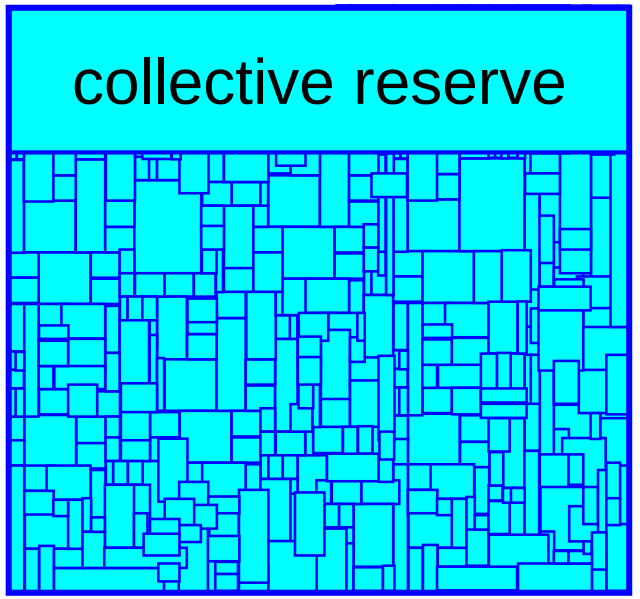
individual saving

(e.g. mutual fund)



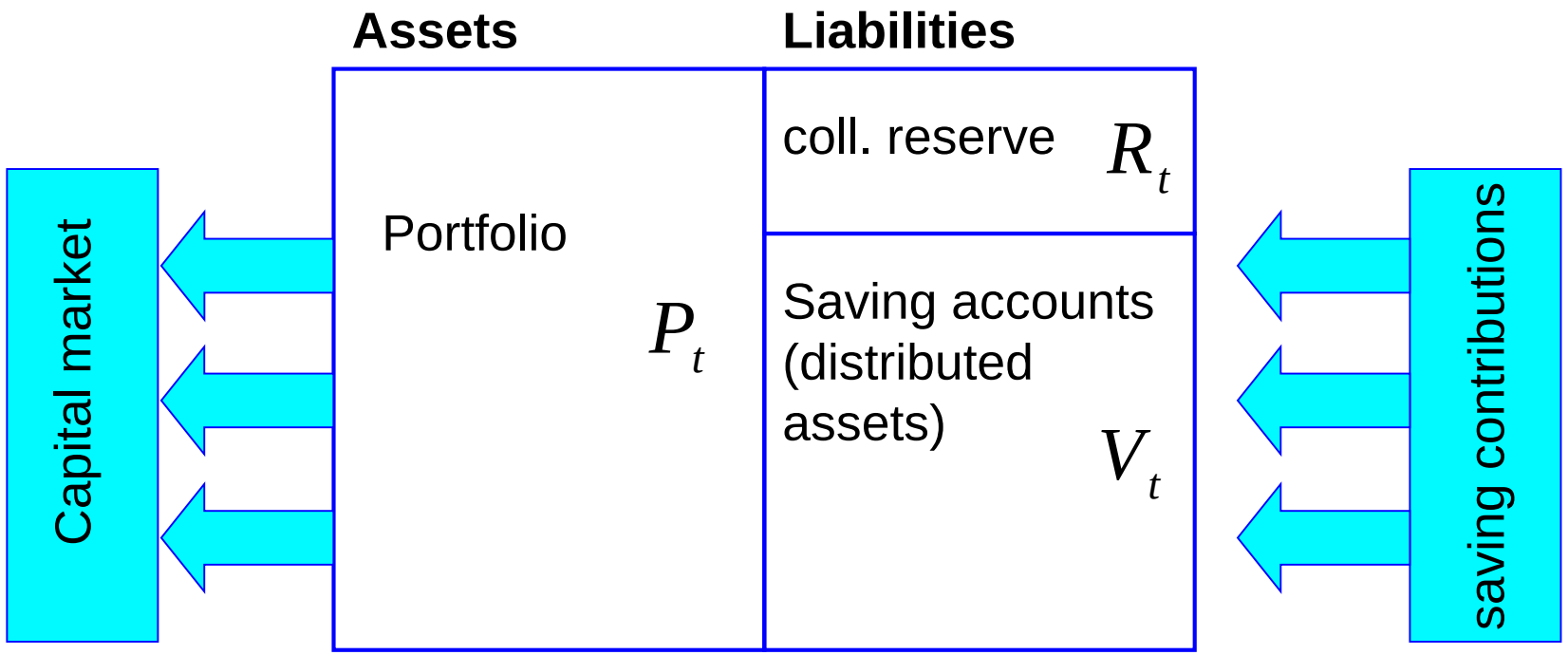
unit price follows exactly the market value of assets

collective saving



part of the assets is not allocated to the individuals

Balance sheet of collective saving model

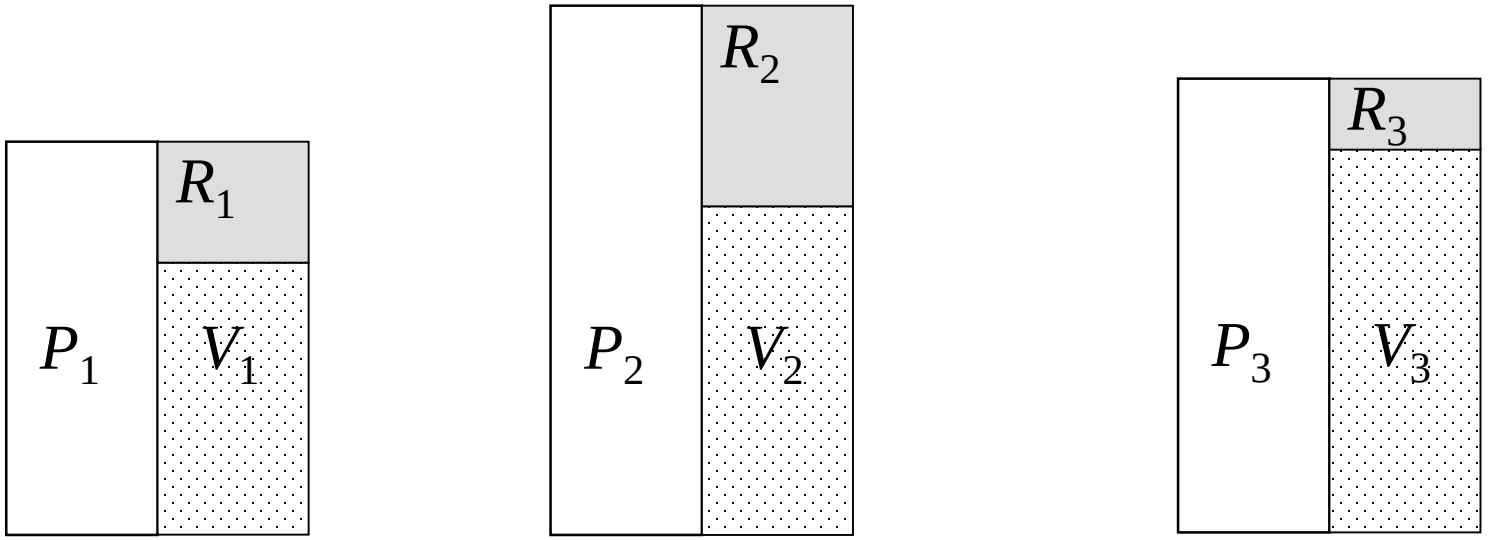


(log-) reserve ratio: $ln\left(\frac{P_t}{V_t}\right)$

Intergenerational Risk Sharing

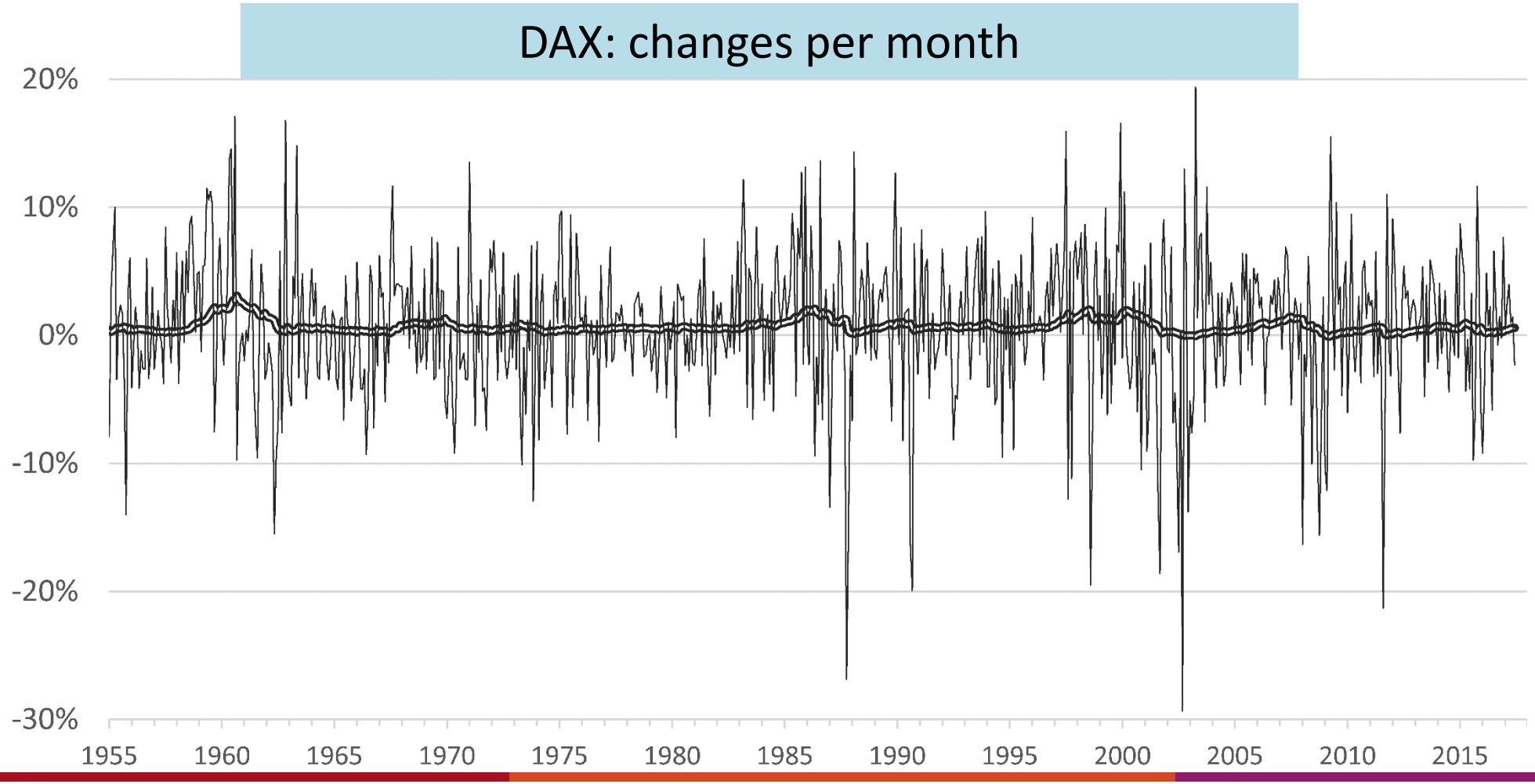
„bull markets“

„bear markets“

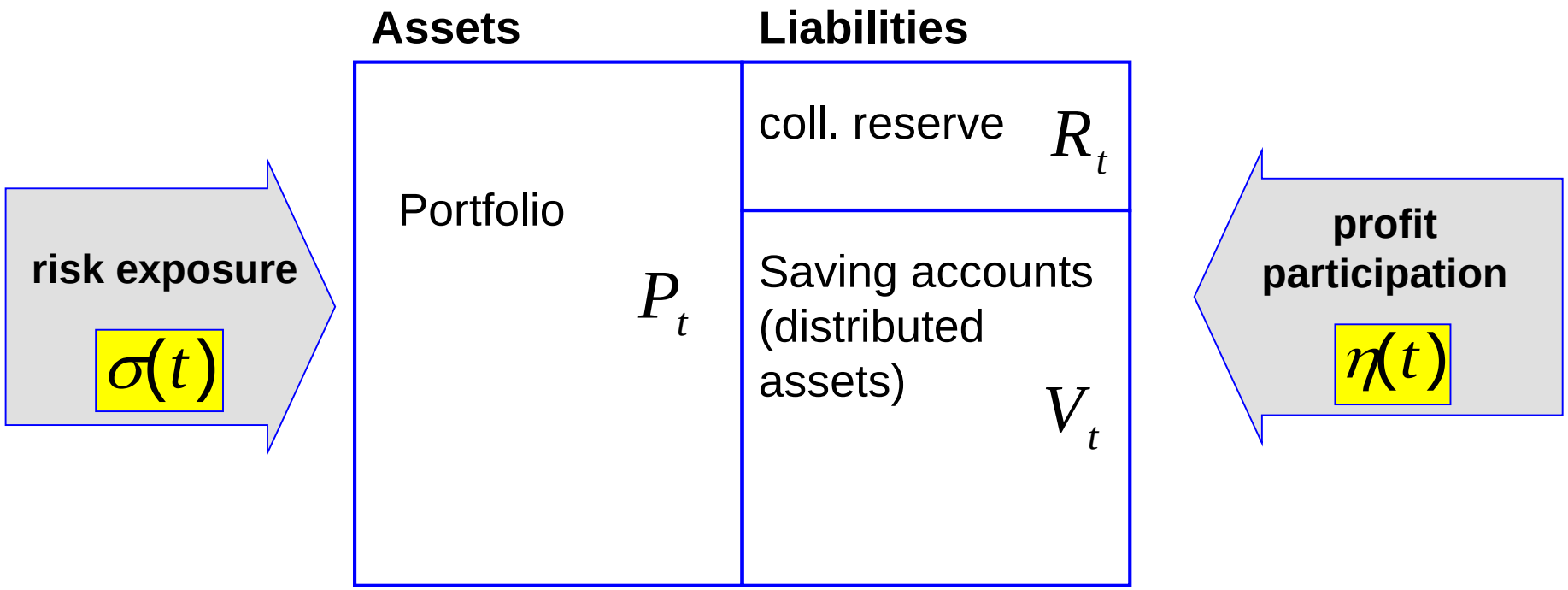


volatile market values are buffered by the collective reserve

Buffering capital market risks



Asset Liability Management



stochastic control: $\hat{\rho}(t) = ln\left(\frac{P_t}{V_t}\right) - \rho_{\text{target}}$

Time Continuous ALM-Model *)

Assets

$$\frac{dP(t)}{P(t)} = \left(\bar{\mu} + r_M\,\sigma(t)\right)dt + \sigma(t)dW_t$$

Liabilities

$$\frac{dV(t)}{V(t)} = \eta(t)\,dt$$

„control“

$$\hat{\rho}(t) := \ln\left(\frac{P(t)}{V(t)}\right) - \rho_{\text{target}}$$

ALM

$$\sigma(t) = \hat{\sigma} + a\,\hat{\rho}(t)$$

$$\eta(t) = \left(\bar{\mu} + r_M\sigma(t) - \tfrac{1}{2}\sigma^2(t)\right) + \theta\,\hat{\rho}(t)$$

expected return on assets

*) Goecke: Insurance: Mathematics and Economics 2013, 678-689.

Solution *)

$$P(t) = P_0 \exp\left(\int_0^t \bar{\mu} + r_M \, \sigma(s) - \tfrac{1}{2}\sigma^2(s) \, ds + \int_0^t \sigma(s) \, dW_s \right)$$

$$V(t) = V_0 \exp\left(\int_0^t \eta(s) ds \right) = V_0 \exp\left(\int_0^t \left(\bar{\mu} + r_M \sigma(t) - \tfrac{1}{2}\sigma^2(t) \right) + \theta \, \hat{\rho}(t) ds \right)$$

$$\hat{\rho}(t) = \ln\left(\frac{P(t)}{V(t)} \right) - \rho_{\text{target}} = \hat{\rho}_0 - \theta \int_0^t \hat{\rho}(s) ds + \int_0^t \left(\hat{\sigma} + a \, \hat{\rho}(s) \right) dW_s$$

$$\Rightarrow \quad d\hat{\rho}(t) = -\theta \, \hat{\rho}(t) \, dt + \left(\hat{\sigma} + a \, \hat{\rho}(t) \right) dW_t$$

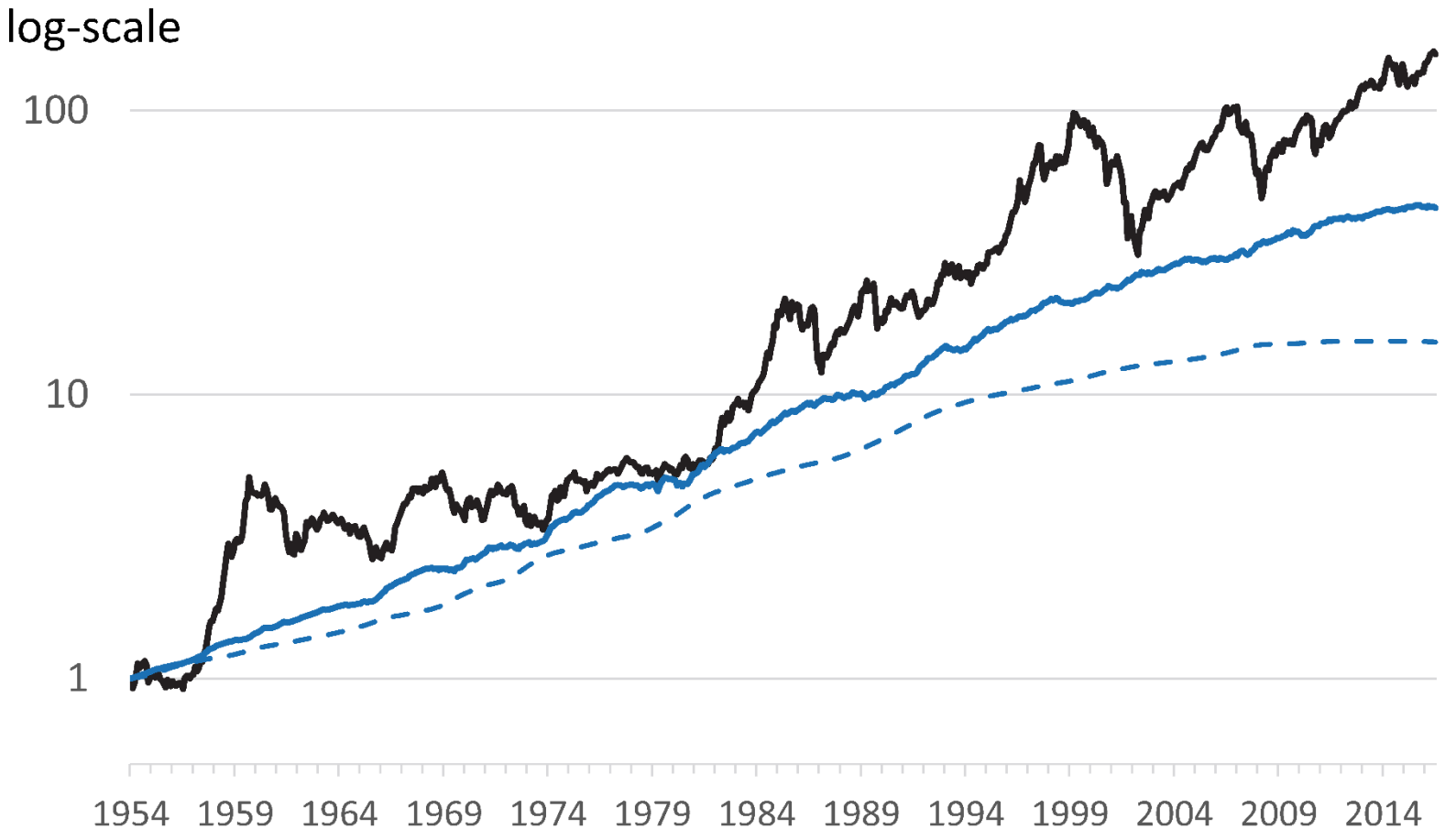
ALM

$$\sigma(t) = \hat{\sigma} + a \, \hat{\rho}(t)$$

$$\eta(t) = \left(\bar{\mu} + r_M \sigma(t) - \tfrac{1}{2}\sigma^2(t) \right) + \theta \, \hat{\rho}(t)$$

*) Goecke: Insurance: Mathematics and Economics 2013, 678-689.

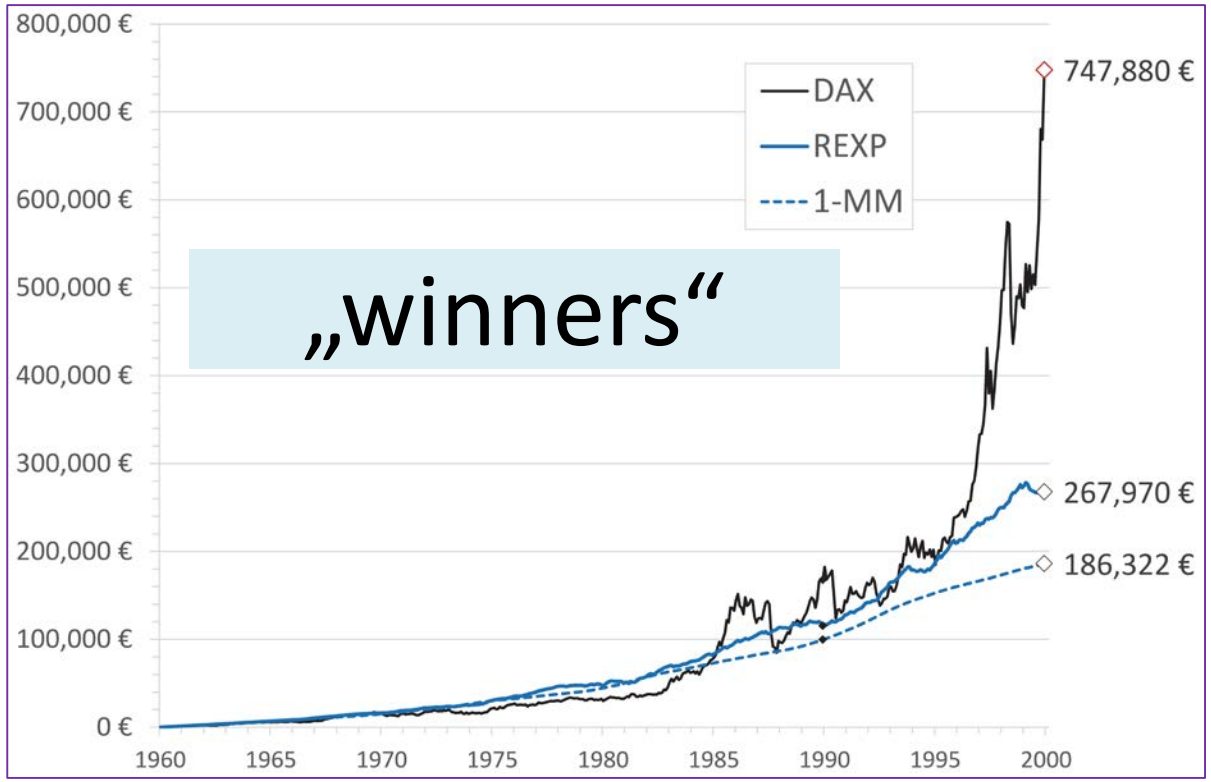
1€ -Investment 01.1955-06.2017



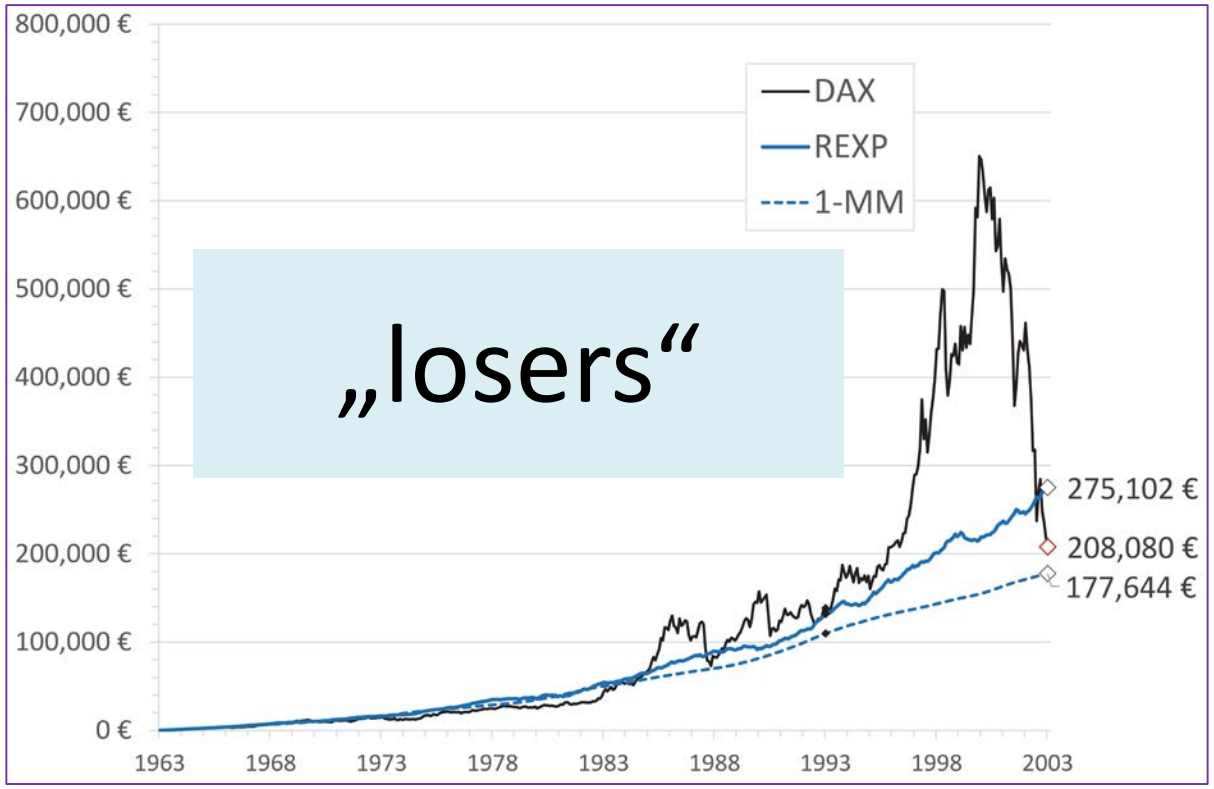
		average return p.a.
stocks (DAX)	**158.85€**	**8.44%**
fixed income (REXP)	**45.45€**	**6.30%**
money market (1-M-Euribor)	**15.33€**	**4.46%**

Accrued Capital

(40year saving plan with saving rate of 100€ per month)



01.03.1960 – 29.02.2000



01.04.1963– 31.03.2003

CDC and Intergenerational Equity

Backtesting (Germany 1955-2017)

ALM

$$\sigma(t) = \hat{\sigma} + a\,\hat{\rho}(t)$$

$$\eta(t) = \left(\bar{\mu} + r_M \sigma(t) - \tfrac{1}{2}\sigma^2(t)\right) + \theta\,\hat{\rho}(t)$$

asset allocation:

- stock portfolio (proxy: DAX) **+** fixed income portfolio (proxy: REXP)
- adjust stock ratio $\beta(t) = \hat{\beta} + a\,\hat{\rho}(t),\ \ 0 \le \beta(t) \le 100\%$

profit participation:

- *expected* portfolio return $\eta^{(e)}(t) = money\,market(t) + \beta(t)\,ERP$
- $\eta(t) = \eta^{(e)}(t) + \theta\,\hat{\rho}(t)$

Calibration:

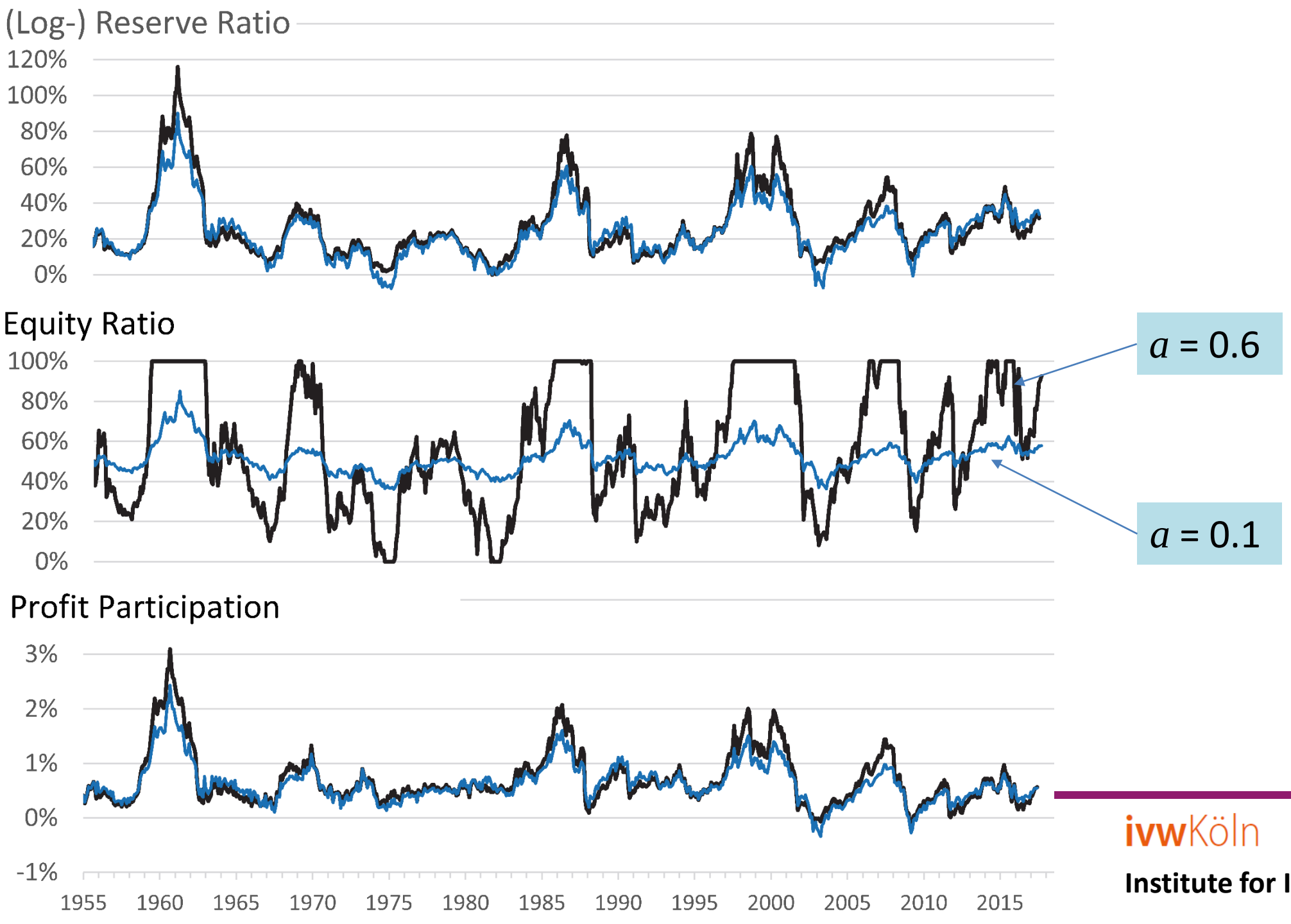
$$\hat{\beta} = 50\%$$

$$a = 0.6$$

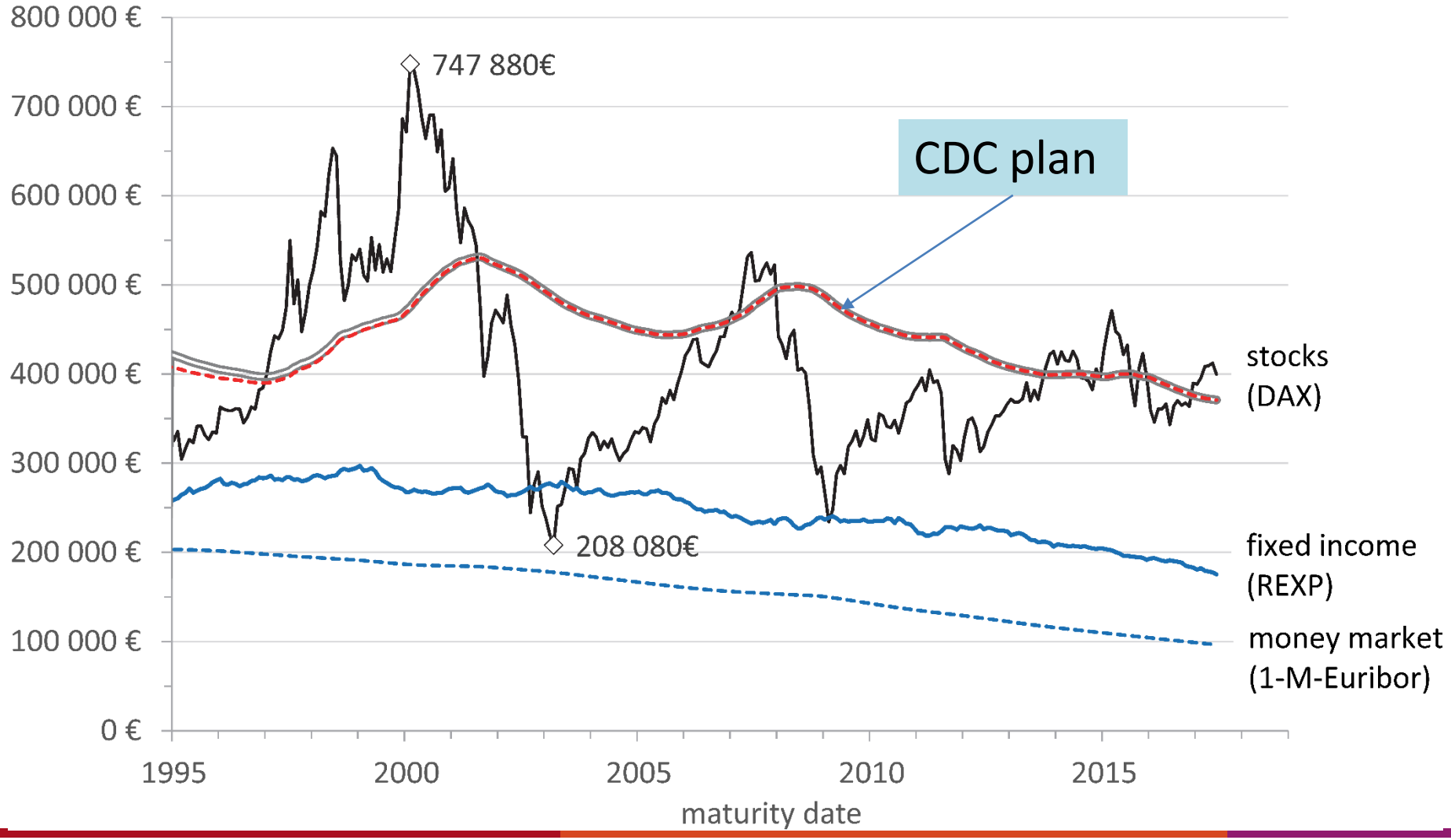
$$\theta = 0.3$$

$$\ln\left(\frac{P_0}{V_0}\right) = 0.2$$

$$ERP = 5\%$$


(Log-) Reserve Ratio
120%
100%
80%
60%
40%
20%
0%
Equity Ratio
100%
80%
60%
40%
20%
0%
Profit Participation
3%
2%
1%
0%
-1%
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
a = 0.6
a = 0.1

CDC and Intergenerational Equity



Summary

- CDC-plan performed extremely well
  …. in the past …. for Germany
- long term guarantees threaten intergenerational equity
- CDC-plans are **resilient**

able to absorb external shocks

able to adjust to fundamental economic changes

Summary

CDC is a good idea -

let‘s work on it!

Thank You for Listening!

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