Negative Interest Rates – Technical Consequences

Discussion

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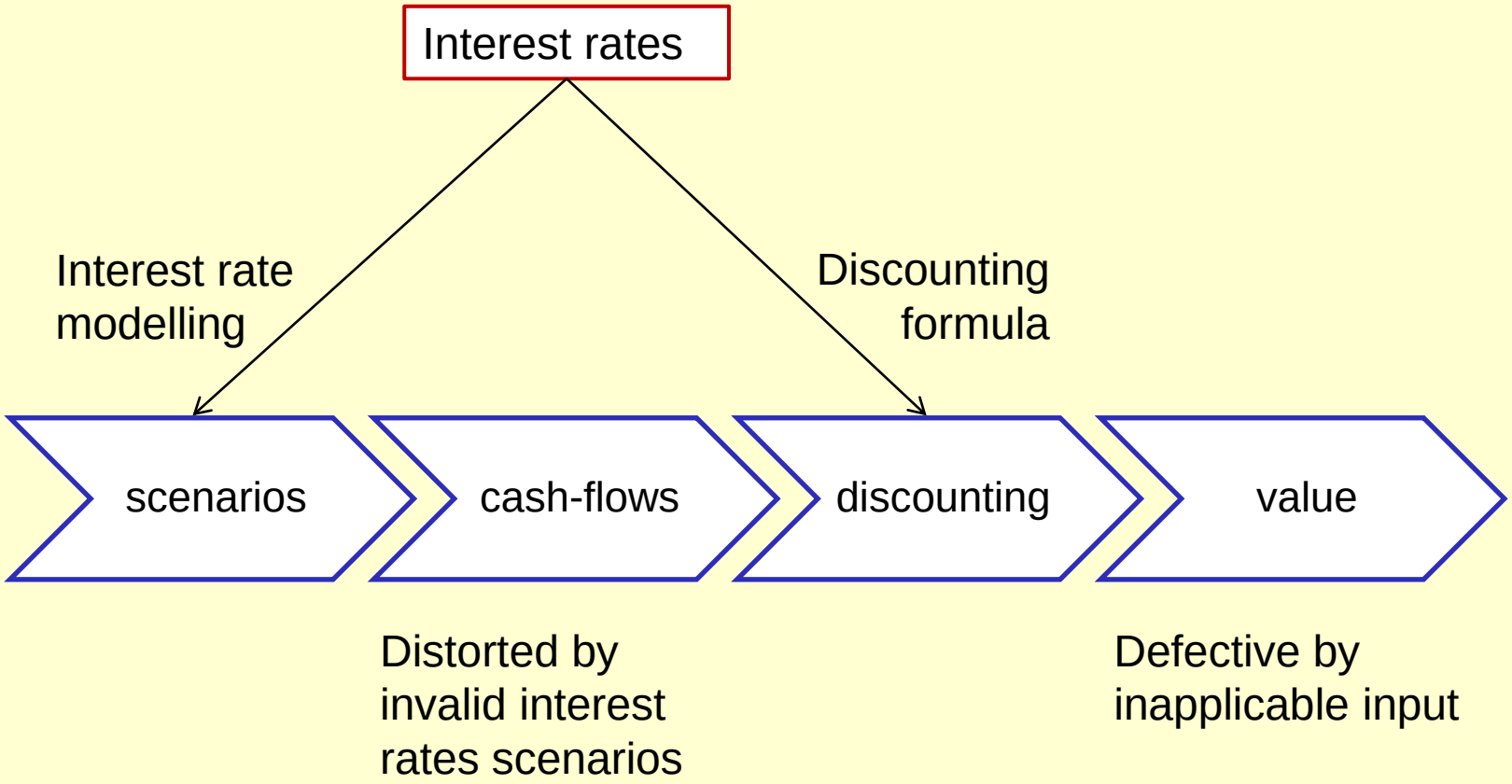
Mathematical and technical consequences of negative interest rates

- Valuation
  - Discounting
- Risk management
  - Scenarios
  - Volatilities
- Pricing
  - Term/Duration
- Tools
  - eg Excel

Valuation Process – problems with negative interest rates



1. Discounting

Formula for Discounted Cash-Flows:

$$DCF = \sum_{n=0}^{\infty} C_n \cdot \left(\frac{1}{1+i}\right)^n = \sum_{n=0}^{\infty} C_n \cdot D^n =$$

$$= C_0 + C_1 \cdot D + C_2 \cdot D^2 + C_3 \cdot D^3 + \ldots$$

- Convergence dependent on Cash-Flow-scenario
- As long as $i > 100\%$

If $C_n \equiv 1$, then eternal perpetuity simplifies to

$$DCF \mapsto P = \frac{1+i}{i}$$

- If $i = 0$, then P infinite
- If $i < 0$, then P negative

Formula not valid in that case!!

2. Interest rate models

- Many stochastic interest rate models, eg
  - Cox-Ingersoll-Ross
  - Black-Karasinski
  - …
- assume, that
  - short-rate > 0
  - volatility proportional with short-rate

- Others (eg Hull-White) allow for negative interest rates
  - However unsystematically

> As mentioned above, the theoretical possibility of r going below zero is a clear drawback of the model (3.32) in general, and of (3.33) in particular.

Quote: Brigo & Mercurio (2006)

2. Interest rate models

- Possible ways out:
  - Normal distribution
  - Parallel shift

- Problems arising:
  - Floor > -100% ?
  - How behaves volatility in the negative area?
  - How behaves volatility at level 0%?

3. Tools eg. MS-Excel

- Problems with certain functions, eg DURATION()

Parameter	Szen1	Szen2
Abrechnung	01.01.2016	01.01.2016
Fälligkeit	31.12.2025	31.12.2025
Nominalzins	5,0%	5,0%
Rendite	3,0%	-1,0%
Häufigkeit	1	1
Duration	**8,27**	**#ZAHL!**

- The same appears with RENDITE(), …

3. Other Tools

- ESG´s face problems
  - For internal models negative interest rate scenarios are required by EIOPA

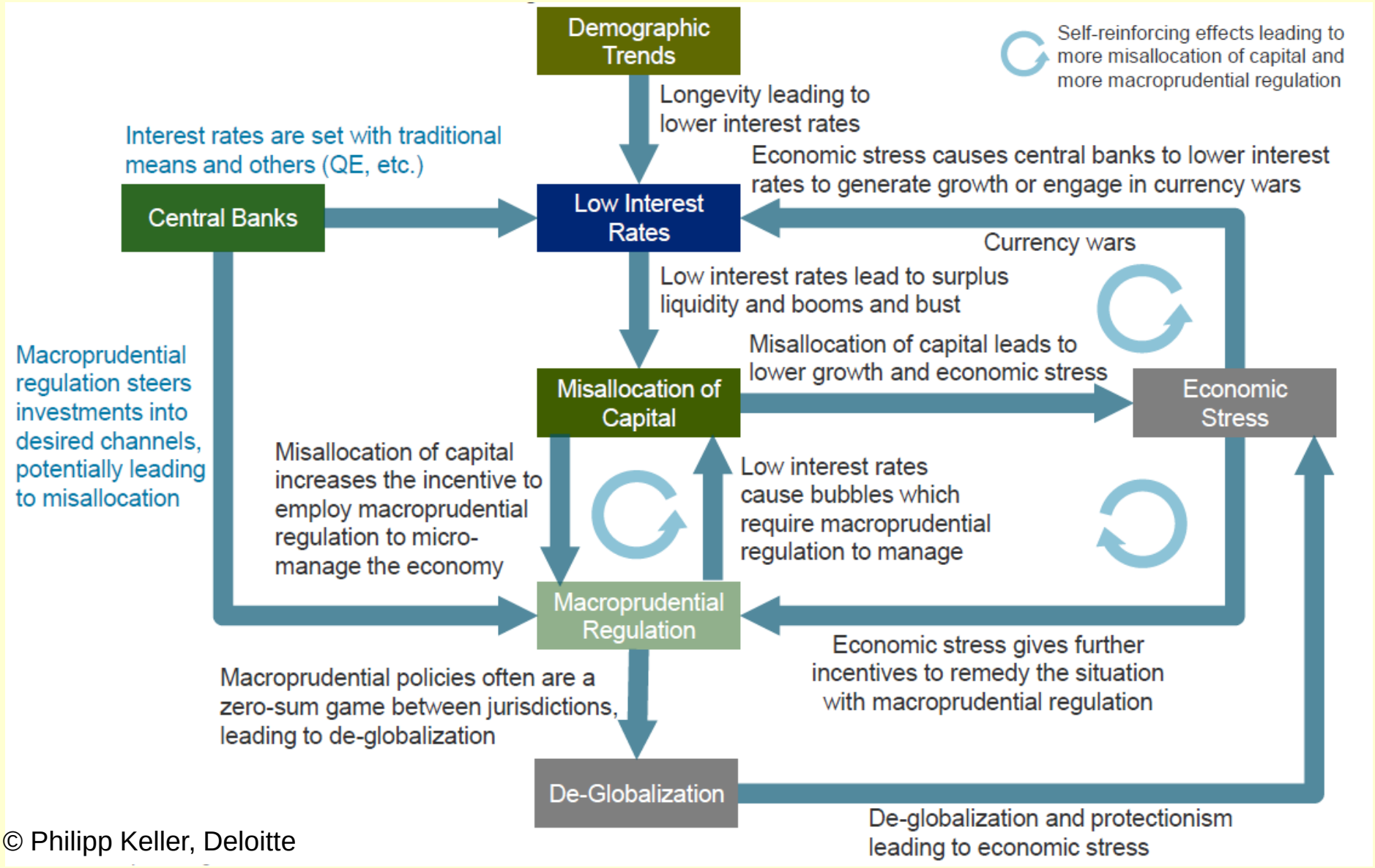
- Not clear: Actuarial simulation tools

- **More evidence requested!!!**

4. Other topics in relation to negative interest rates

- Accounting
  - IFRS 9, IAS 39; IFRS 17, IFRS 2
  - Hedge Accounting
  - Presentation of interest income and costs IFRS
  - Accounting Unit, Balancing prohibition
  - Pension provisions, mid/long-term liabilities
  - Fair Value
  - Impairment
- Risk Management
  - Effective interest rate
  - Cash-flow-Hedging
  - Cross-currency-Swaps (Floors, …), Floors, Caps
- Business appraisals
  - Risk charge on negative interest rates

5. Insidious secondary effects of negative interest rates



Rationale for a Lower Bound in Interest Rate Models

Capital Market Models: Legal Requirements

According to Article 22, Section 3 of the Commission Delegated Regulation (EU) 2015/35, a model providing projections of future financial market parameters for the valuation of technical provisions particularly has to comply with the following requirements:

a. *it generates asset prices that are consistent with asset prices observed in financial markets;*

b. *it assumes no arbitrage opportunity;*

c. *the calibration of the parameters and scenarios is consistent with the relevant risk-free interest rate term structure used to calculate the best estimate as referred to in Article 77(2) of Directive 2009/138/EC.*

Classification of the asset "Cash"

Bank deposits can be replaced by cash, since

- cash is a legal tender.
- cash withdrawal is not limited.
- cash storage is not limited.
- The level of demand for cash determines the volume of cash that circulates: According to the current legal situation, the volume of cash has to be increased in case of a rising demand.*

Consequently, negative interest rates on bank deposits can, ceteris paribus, be avoided through holding cash.

* It cannot be ruled out that future legal amendments might change this situation. However, it is necessary and reasonable to base the following considerations on the current legal framework.

Disadvantages of the asset "Cash"

- Physical delivery impairs "fast transactions".
- Transaction costs increase with rising transaction volume and speed.
- Additionally, friction costs for storage, protection, insurance, etc. need to be considered: the physical possession of cash creates difficulties in terms of liquidity management and does not enable the insured to be settled quickly.

The costs of holding cash depends on the frequency, the speed and the volume of transactions.

Insurers' costs of holding cash are lower than for other sectors where fast and large transactions are more frequent.

Cost of Holding Cash at Insurance Companies

The actual level of cost from holding cash is company-specific and needs to be determined individually, for example[1]:

a) costs for storage and insurance:	*20 bps*
b) costs of transportation:	*20 bps*
	40 bps

Whenever the short-term interest rate falls below the costs of holding cash, the insurance company would progressively move into cash.

The interest rate for short-term investments (e.g. the yield on short-term government bonds) can fall below the costs of holding cash[2], since those assets can generate value to non-insurance investors due to their specific properties (e.g. fast and low-cost tradability – properties which cash does not possess).

[1] Fictitious values that do not refer to a specific company, but might be close to reality.

[2] This does not imply arbitrage opportunities for insurance companies since they cannot issue government bonds.

Explicit Modelling of the Asset Class "Cash" (1)

The valuation model becomes complex for the following reasons:

- The fixation of the nominal value of cash violates the no-arbitrage principle which implies that goods with identical future cash flows must have identical current prices ("law of one price").
- The current value of a cash available in the future is given by the nominal value minus its discounted costs (storage, protection, etc.). Accordingly, the valuation of cash and bank deposits will generally differ.
- Hence, the martingale test will fail for the asset class "cash" ("1<1").
- In order to capture the theoretical arbitrage opportunity, an insurance company would have to earn the short term interest and simultaneously lend out money at cash conditions.
- But: Only the ECB is able to issue cash and to benefit from favorable market conditions regarding cash.

Approximate Approach

The impact of the „cash option" can be approximated via interest rate models with a lower bound:

Approach:

- Insurance portfolios can be valuated on the basis of interest rate models featuring a lower bound for interest rates. This reflects the current reality of insurance companies [1)].
- Such a lower bound should be materially smaller than the cost of holding cash, in order to avoid negative impacts on stability and results of calculations.

[1)] Note that this does not necessarily imply an increase of the capital position:
Scenarios with extremely negative interest rates might not appear, but the relative weight of scenarios with low rates – that generate stress for capital positions – has to increase.

Approximate Approach

Calibration:

- The lower bound is defined taking into account all relevant and public financial data.
- Using directly costs of holding cash to calibrate a lower bound can be difficult from an operational view and such lower bound could have negative impacts on stability and results, trajectories being artificially pulled upwards.
- The notion of lower bound is rather a long-term reference that should not be modify at each reporting date (much like the UFR). A stable parameter could be defined by varying the initial conditions so as to provide a valid level in a broad spectrum of market conditions.
- The relevance of the lower bound can be verified controlling namely the replication of options and zero coupon bond prices.

Lower Bounds on Interest Rates in Practice

- Models with a lower bound for interest rates are widely used in Europe.
- The lower bound can be seen as an additional parameter to improve the calibration of the model.

- Furthermore, the valuation results benefit from
  - ✓ a reduced dependency of results on random seeds,
  - ✓ an improved speed of convergence as well as
  - ✓ an enhanced level of confidence due to the avoidance of potentially flawed impacts from modelled management actions in economic environments substantially different from past and current experiences

The lower bound helps to stabilize the results of the valuation.

THANK YOU!!

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