

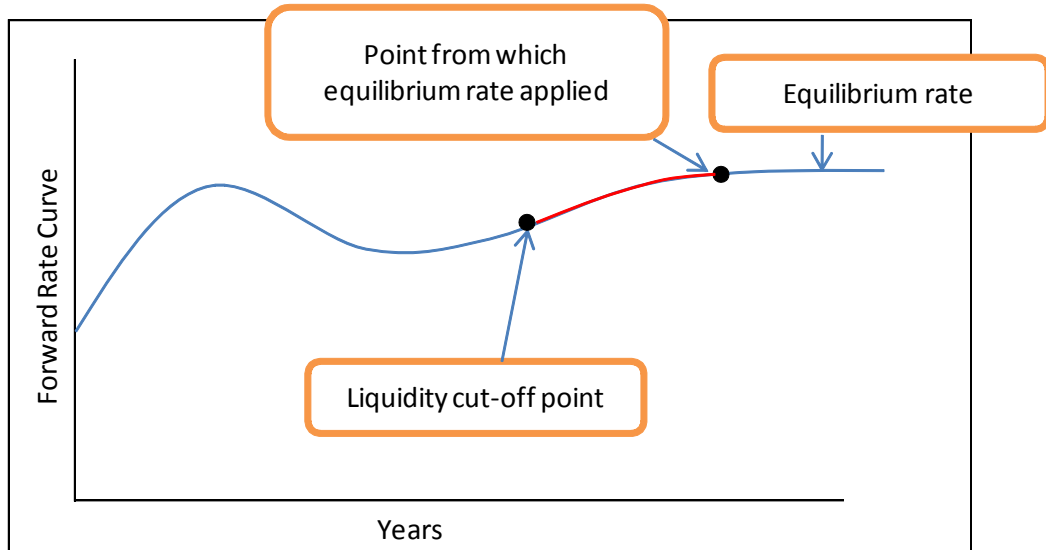
## Examples of the Macroeconomic Extrapolation of the benchmark risk-free yield curve

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<b>Pages:</b>	11		

### 1. Introduction

- 1.1 In the paper “CEA paper on Risk free interest rate principles”, some principles for extrapolation of the interest rate curve were proposed by the CEA. These principles were:
- **Consistency** with the objectives of Solvency II
  - **Risk manageable** – the method should facilitate risk management, which in practice means that there should be a meaningful link between the liquid part of the curve and the non-liquid curve so that use can be made of liquid hedging instruments.
  - **Economic valuation** – as far as possible the extrapolation should reflect economic realities, i.e. the long term economic equilibrium position as opposed to a mechanical extrapolation that results in economically counter-intuitive and inconsistent results.
  - **Reduce pro-cyclicality**
  - **Compatibility with market-consistency**
  - **Parsimony** - the least complex appropriate approach should be adopted. In general this means methods involving fewer and simpler parameters, which helps achieve harmonisation and long-term stability.
- 1.2 With this paper we aim to discuss possible methods to apply of these principles in practice, with examples for the calculation of the main parameters required in the extrapolation.
- 1.3 We note that this paper discusses one possible methodology to extrapolate the yield curve, which in principle could be applied to all markets. However, we don't preclude that other methodologies would be more appropriate in specific markets.
- 1.4 The main parameters to be defined in the application of any extrapolation method are:
- The liquidity cut off point - i.e. the longest tenor up until which point market data is considered liquid.
  - The method to use to move from the liquid part of curve to the long-term equilibrium rate
  - The tenor from which the equilibrium rate is to be applied

- The long-term equilibrium rate.



- 1.5 We note that in its Final Advice based on CP40, Ceiops states that high volatility of the long end of the term structure can lead to pro-cyclical effects and that the choice of the extrapolation technique should take into account the effect on financial stability. Consequently, Ceiops supports the allowance for some mechanism that may provide stability to the outcomes of the extrapolation. We strongly support this view.

## 2. Macroeconomic extrapolation – summary of one possible methodology

- 2.1 It is very important that supply and demand factors in the asset side of the market do not dictate the value of long term liabilities. If one were to use the market interest rate directly as an estimate of the expected long term rate, then long-term liabilities may be significantly over- or under-estimated due to supply and demand imbalances, especially in certain markets or in times of financial turmoil. In the example methodology we make use of what we define to be the "*liquidity ratio*". The liquidity ratio, described in section 5, is designed to take into account the imbalances in supply and demand between the bond/Swap market and the insurance liabilities which these assets will be held to meet.
- 2.2 One possible methodology for setting the benchmark risk-free yield curve can be summarised as follows:
- Where market data is available and reliable, and the market is considered to be deep and liquid, then the benchmark risk-free forward rate should be calculated based on market data.
  - Where market data is not available or reliable, then the benchmark risk-free forward rate should be set to be the long-term equilibrium rate. Where this long-term equilibrium rate could be calculated as follows:
    - As a moving average of historic long-term nominal forward rates when this data is available and reliable, i.e. the current lack of data is due to abnormal market conditions – discussed in section 3 of this paper.
    - When no reliable historic long-term forward rates are available, i.e. the lack of data is a permanent market feature; the long-term equilibrium should be estimated as the sum of the assumed long term real rate, the official inflation target and a "term premium" – discussed in section 4 of this paper.
  - Between these two points, where the market is not considered deep and liquid, but there is some reliable and available market data, then a combination of the market data and the equilibrium rate could be used. The proportion of each to use could be measured by the "*liquidity ratio*", which also provides a method to determine the liquidity cut-off point, as well as the point in time from which the equilibrium rate is to be applied - discussed in section 5 of this paper.
- 2.3 This example methodology will extrapolate forward rates. A spot curve would then need to be constructed on the basis of the forward rate curve.
- 2.4 Within a specific currency area, one unique method should be used and there should be one unique forward curve set per currency in order to ensure a level-playing field is retained.
- 2.5 The proposed general principles, discussed in Para 1.1 should apply to all currency areas, but due to varying market conditions the implementation for different currency areas may vary to some extent.
- 2.6 We should note that when stressing interest rate risk as part of the calculation of the SCR, the volatility of the resulting extrapolated interest rate curve should be taken into account.

### 3. The macroeconomic long-term equilibrium rate in markets where there exists reliable historic market data

- 3.1 In those cases where reliable market data cannot be observed directly due to abnormal market conditions, it must be estimated. Economic theory assumes that market prices are close to their equilibrium level in the long term.
- 3.2 When reliable historic market data exists, the long-term equilibrium level could be estimated by means of an average of actual historic market observations (this could, for example, be an average over 10 years of data).
- 3.3 Note that the long end of the interest rate curve may be distorted due to supply and demand factors and so therefore be subject to technical bias. We note that Ceiops raised the need to minimise technical bias in the risk-free yield curve in their final advice on CP40. We agree with this view - a long-term moving average could minimise any short-term supply and demand distortions.
- 3.4 We note that supply and demand imbalances can exist in the Euro market. More analysis is required to conclude at what point in the yield curve the long-term equilibrium level would need to be used.

## 4. The macroeconomic long-term equilibrium rate in markets where there is inadequate market data

- 4.1 Where there is inadequate market data and this is a permanent market feature, the long-term equilibrium rate may be estimated by an alternative method to set the long-term rate in each currency area.
- 4.2 For these markets, an option would be to calculate the long-term equilibrium rate as the sum of the following macro-economic estimates:
  - The assumed long term real rate
  - The official inflation target
  - A “term premium” – which represents the additional return expected to compensate for longer-term investments.
- 4.3 We note that this methodology would seem particularly appropriate for markets such as Sweden or Norway.
- 4.4 The official inflation target in the model is the inflation target of the currency’s central bank. For some markets the inflation target is relatively stable over time. However, for some currencies there is a risk that the inflation target of the central bank could change overnight and hence produce a jump in the model equilibrium rate. Our recommendation is that changes and revisions are gradually introduced over time (for example over the next year) in order to make sure that there are no abrupt changes to the curve.
- 4.5 The assumed long term real rate would typically be estimated both by the central banks and the national statistics agencies. Historical data can give an indication of the expected real rate, however, ideally one should make use of a forward-looking expectation. Again it is important that revisions are introduced gradually in the model.

## 5. An example as to how to move between market data and the equilibrium rate using the "liquidity ratio"

5.1 We have introduced the concept of the "liquidity ratio" which we believe could address:

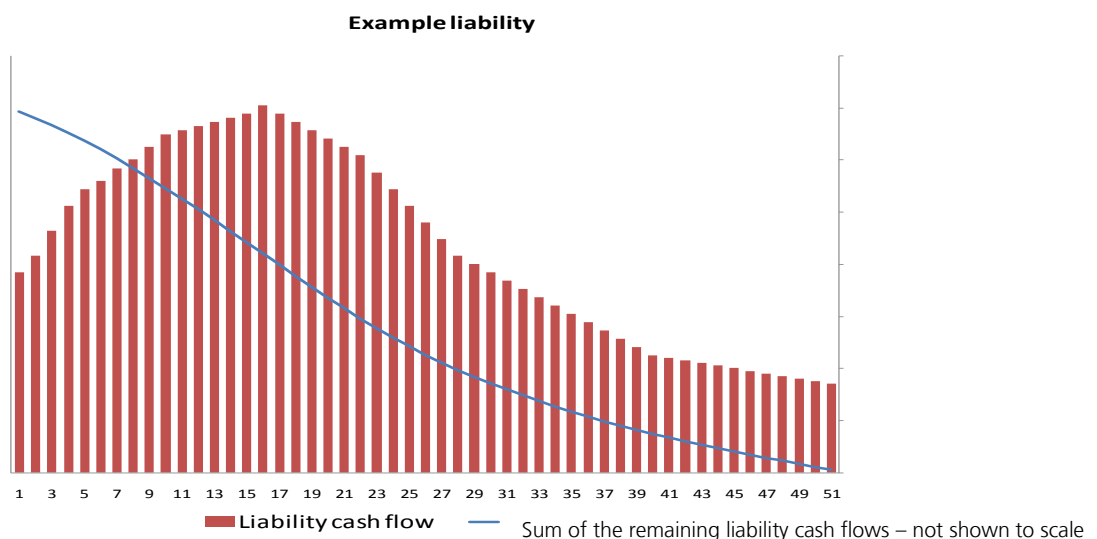
- The problem of defining the liquidity cut-off point i.e. the point at which the yield curve starts to move towards the long-term rate and so market data is no longer fully used;
- How to define the point in the yield curve from which the forward rate is set equal to the long-term equilibrium rate; and
- How to move between the liquidity cut-off point and the long-term equilibrium rate.

### How to calculate the "liquidity ratio"

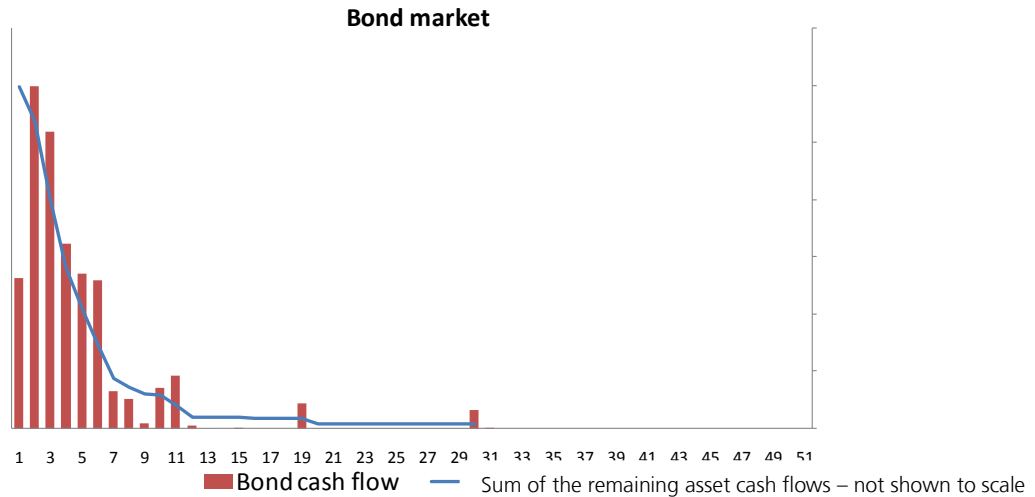
5.2 We define the liquidity ratio by looking at the total size of insurance and pension fund liabilities in the market (nominal guaranteed future cash flows to policyholders) and comparing this with the return cash flows generated by the bonds (corporate and government)/swaps available in the market.

5.3 In some markets the predominant part of liabilities in the long-end of the curve will be life insurance liabilities, but most of the assets issued in that market could have significantly shorter duration. In defining liquidity it is essential that the maturity mismatch between liabilities and available bonds is considered. To the extent that market data is available, the imbalance between supply and demand should be taken into account when determining from which point in the curve an extrapolation method should be used.

5.4 Consider the following graphical example which shows the total expected liability cash flows for each future year in a certain market. From this data, at any given point in time, one can calculate the sum of the remaining amount of the expected liability cash flows.



5.5 One can consider the bond/swap market in a similar manner. For bond markets, the total expected coupon and capital cash flows for each future year in the market and consequently the sum of the remaining amount of these amounts can be easily calculated.

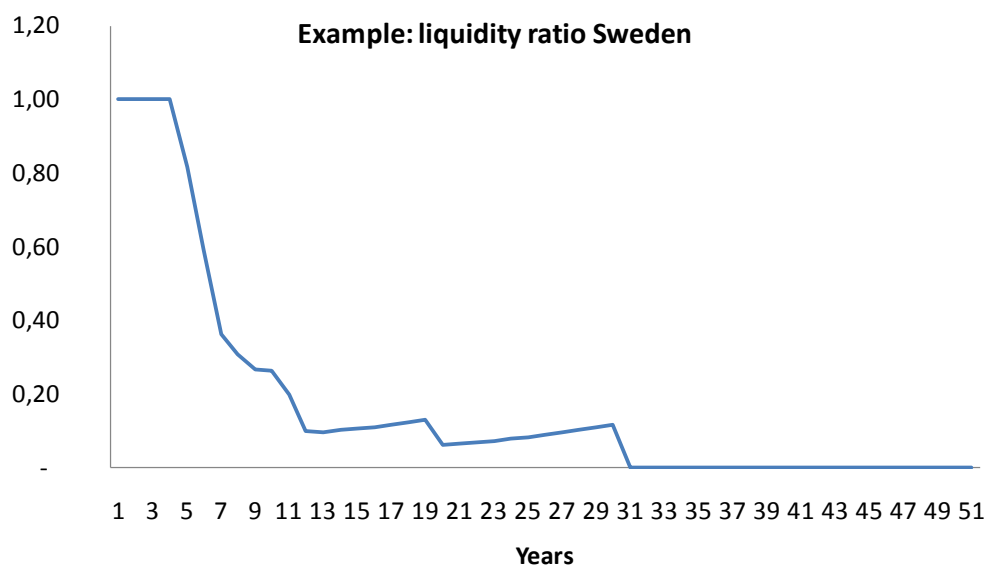


5.6 The “*liquidity ratio*” is then defined as:

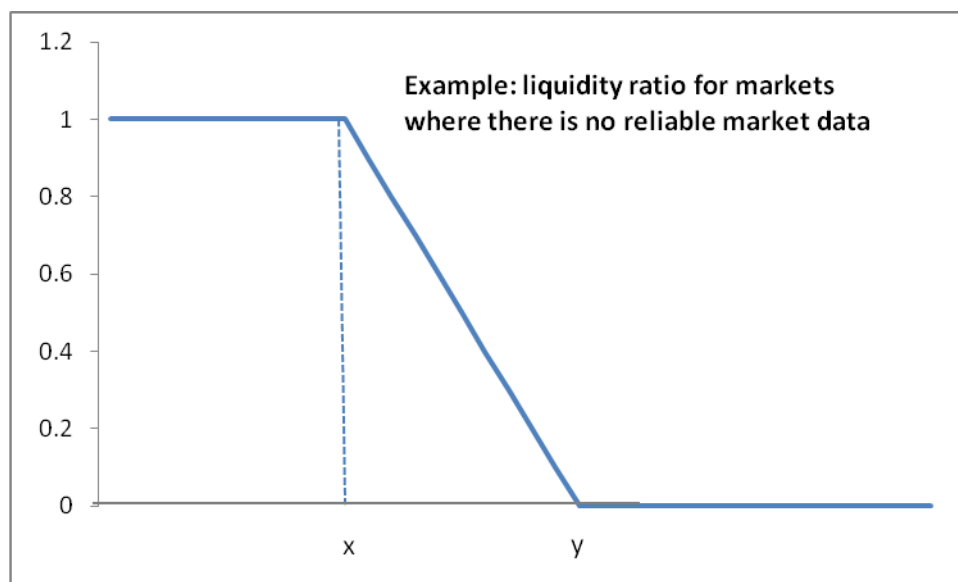
**Liquidity ratio = cumulative sum of bond cash flows / cumulative sum of liability cash flows**

This is calculated looking at the total future cash flows expected in the market for each tenor and is capped at 1.

5.7 If the ratio is one this indicates that the market is expected to be liquid. While a ratio closer to zero indicates an illiquid market.



- 5.8 If there is reliable data both on the liability side and in the bond/swap market, this information could therefore be used to calculate the liquidity ratio for any given year.
- 5.9 However, if there is no reliable input data, an estimate of a liquidity ratio would be required. In this case, a simple liquidity ratio could be set to run-off linearly. For example (where 'x' and 'y' would need to be determined for the relevant market):



#### How to use the "liquidity ratio"

5.10 At any point in the yield curve the liquidity ratio could define the transition between market rates and the long term equilibrium rate in the benchmark yield curve as follows:

- If the liquidity ratio equals one - that part of the curve will be set to the current market forward rates.
- If the liquidity ratio equals zero - that part of the curve will be set to the long term equilibrium rate.
- If the liquidity ratio is between zero and one, that part of the curve will be defined as follows:  

$$\text{liquidity ratio} * \text{market rate} + (1 - \text{liquidity ratio}) * \text{long term equilibrium rate}.$$

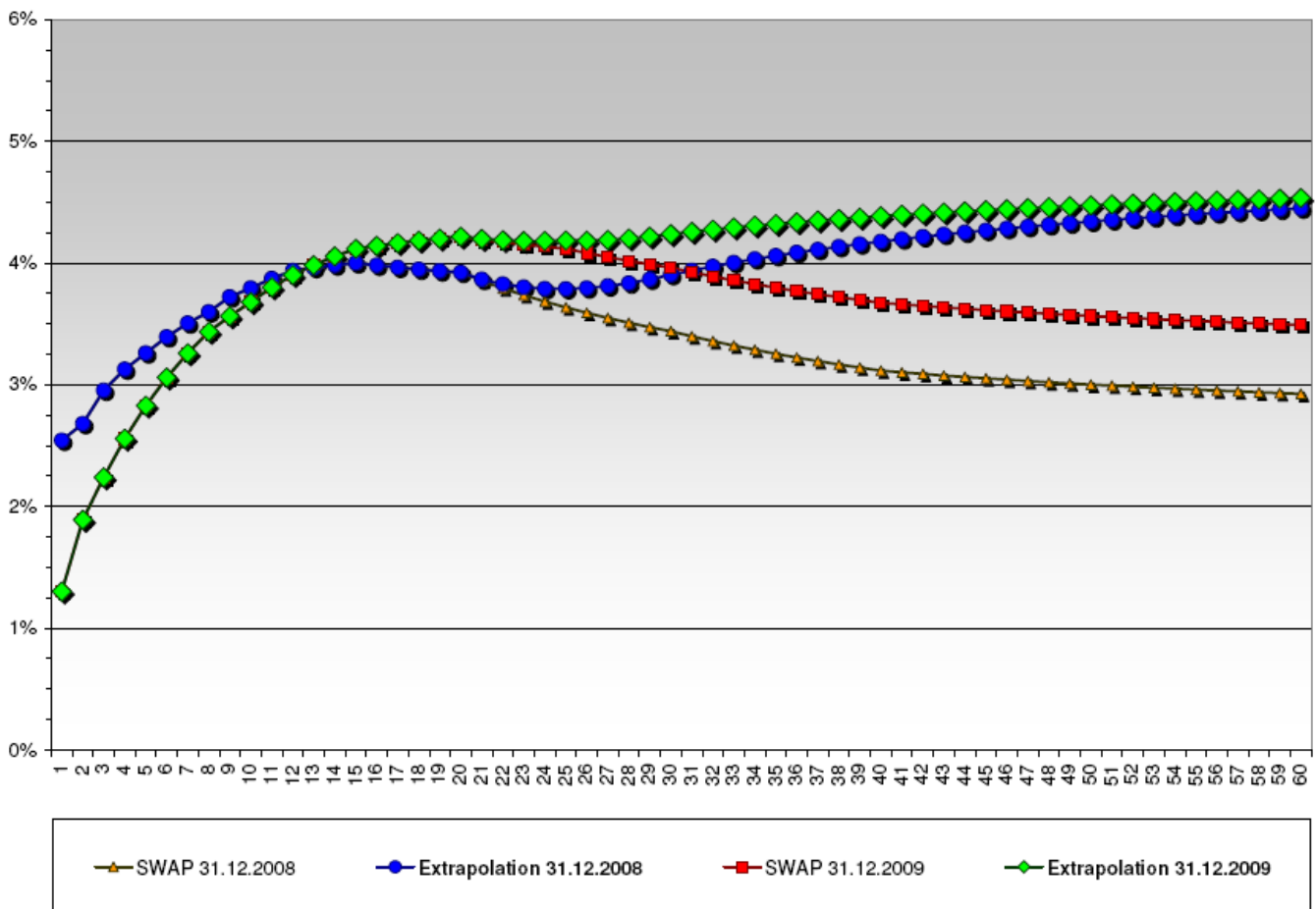
#### Recalculation of the "liquidity ratio"

5.11 It is not considered reasonable to continually update the liquidity cut-off point, or the point at which the long-term rate is applied, because frequently changing parameters would result in unnecessary volatility and could be subject to arbitrary judgement. An implementation which is not expected to shift significantly over time, such as the simplified example in Para 5.9, may add to the robustness of the model, however unnecessary distortions or arbitrage opportunities should be avoided.

## 6. Determining the benchmark risk-free yield curve - examples

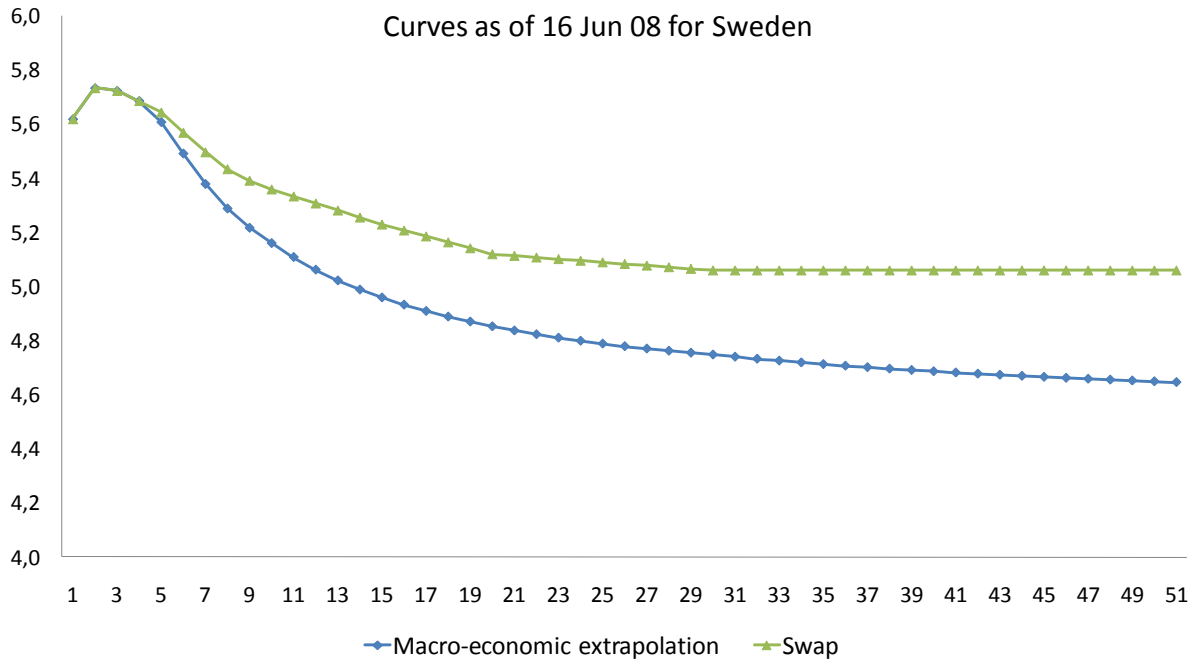
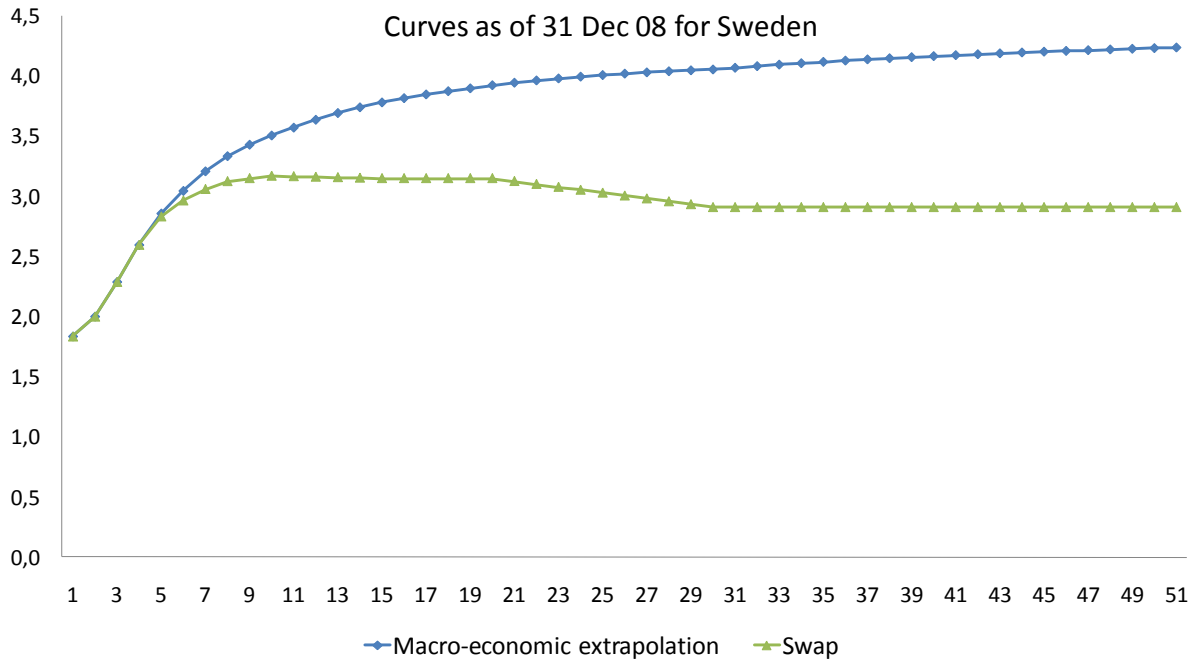
6.1 Once a model forward rate curve is constructed, then this would be used to construct a spot rate curve.

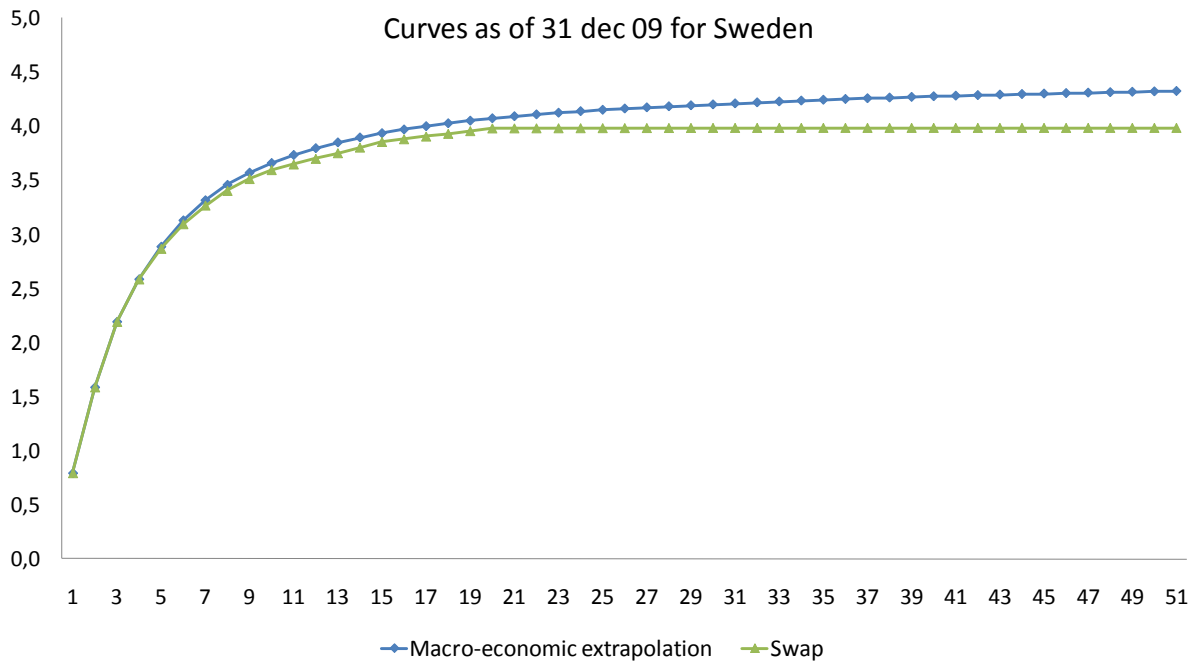
6.2 From the extrapolation methods available, one possible example for the Euro market is shown below. The example assumes that the Euro market is illiquid at the long end of the curve at 31 December 2008 and at 31 December 2009 and so therefore an extrapolation method is used. This example uses an extrapolation method which converges to a long term equilibrium rate which we have assumed to be the average of the previous 10 years of historic forward rates. As we do not have reliable input data to calculate the liquidity ratio according to paragraph 5.6, we make use of the simplified approach as presented in paragraph 5.9. Furthermore, we have made an assumption that the transition to the long term equilibrium rate is between years 20 and 30. We note that this example is just one possible simulation for explanatory purposes. In particular, the definition of the transition period (i.e. the 20 to 30 years in our example) should be analysed further.



6.3 Below are examples for the Swedish market at three different dates, where the long-term rate is estimated as per section 4 of this paper (i.e. the lack of market data at the long-end of the curve is a permanent feature of the market), based on the estimated liquidity ratio for the Swedish market (shown in Para 5.7). We also compare it to the Swedish swap curve. Particularly at the end of 2008, the swap and government bond rates were at very low level indeed. Much of the fall in rates was driven by market distortions. We argue that these low levels are not representative of expected economic realities and it is important that

excessive volatility that is generated by the absence of a deep and liquid market is avoided, while the macro-economic extrapolation methods converge to the long term equilibrium rate.





6.4 It should be noted that in a high interest rate environment (e.g. summer 2008), the macroeconomic extrapolation curve will be lower than the one based on observable swap market rates with linear extrapolation after the last data point. Hence the extrapolation technique serves as a stabiliser both in low- and high-yield environments, reducing pro-cyclical behaviour. Ultimately these dynamics are expected to reduce adverse impacts of excessive market volatility as well as reduce excessive risk-taking, and hence ensure financial stability both in distressed as well as euphoric markets.

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