1.1 Management Summary

The Liquidity Coverage Ratio (LCR), of Basel[III] sets the bank's potential cash outflows in relation to its capacity to counterbalance them by creating hypothetical inflows from assets which are believed to be repoable or saleable. The implementation of the LCR in a bank seems to be a straightforward exercise, which can somehow be seen as decoupled from the more sophisticated internal models a bank might use to manage its funding liquidity economically.

If a bank, however wants to be able to manage the LCR not only monthly in retrospective – as mandatory in Basel [III] – but on an on-going, forward-looking basis, it will need to simulate its future balance sheet. This is already very near to economic risk management techniques.

1.2 The LCR - Liquidity Coverage Ratio

In the LCR the bank's total net cash outflows of the first 30 calendar days are cumulated in time and compared with the stock of high-quality liquid assets. Assuming that the parameters defined by Basel[III] are realistic, the LCR can be interpreted as survival period of at least 30 days.

The inequality to be met by the bank is expressed in the form of a ratio:

$$\frac{\text{stock of highly liquid assets}}{\text{total net cash outflows over the next 30 calendar days}} > 100\%$$

1.2.1 The Stock of High-quality Liquid Assets

The expression 'high-quality liquid assets' (HLA) is used in Basel [III] with two distinct meanings. Firstly it describes all unencumbered and not rehypothecated assets of the bank that can assumedly be converted easily and fast into cash without generating substantial losses.[1] Secondly it means the amount of liquidity that can be created by liquifying the HLA within a fixed time horizon of 30 days.
The HLA fall into two categories: level1 assets and level 2 assets; the latter can comprise up to 40% of the stock

- level 1 assets: cash & available central bank reserves; liquid marketable government-type assets with a zero RWA[2] - but not with a bank as issuer
- level 2 assets (minimum haircut of 15%): same as level 1 but: 20% RWA - but non-bank corporate and covered (mortgage) bonds included, historical haircut / price decline ≤ 10% (30 day period).

[1] All HLA should ideally be central bank eligible, but not every central bank eligible asset is automatically a HLA.
[2] RWA = Risk Weight Asset under Basel2 standardized approach.

1.2.2 The Total Net Cash Outflows

The Total Net Cash Outflows comprise all expected cash flows derived from the outstanding balances of the bank's assets; respectively liabilities or off balance sheet (OBS) commitments which mature within 30 days, multiplied with expected run off / draw down rates.[3]

- inflows: from liabilities and OBS commitments;
- outflows: from receivables
- net cash outflows := outflows – min{inflows; 75% of outflows}

1.2.3 The Ratio as an Inequality

As inflows and outflows are positive numbers the inequality can also be written as:

stock of highly liquid assets **>** total net cash outflows

The rationale behind this is, to require from banks a balance sheet structure where potential cash needs within the first month are covered by liquidity which is generated by liquid assets: HLA + total net cash outflows > 0

1.2.4 LCR – First Considerations

The LCR is specified as a mixture of a balance sheet and cash flow view. The (complete) set of a bank's transactions (assets, liabilities and OBS commitments) is transformed into a sum of cash outflows and inflows at the end of the considered time horizon.

Today (t=0) the bank's assets will match its liabilities by definition[4]. Going forward in time, assets and liabilities will not mature uniformly. If tomorrow (t=1) *more liabilities than assets mature*, the bank has a *negative liquidity mismatch* because there are more outflows from liabilities than inflows from assets; if less liabilities than assets mature, the bank has a *positive liquidity mismatch* because there are less outflows from liabilities than inflows from assets. Negative mismatches however can only exist as forecasts but not in reality (the central bank will cease payments on the bank's nostro before it 'turns negative'). Therefore the bank has to ensure that it will be able to create at least enough liquidity to counterbalance the forecasted cash deficit. In the LCR, a qualified asset (HLA) thus results in a cash flow by multiplying its available amount with its market price (which is diminished with a haircut).

1.2.5 Lacking term structure of the LCR

In an economic liquidity risk view (the Forward Liquidity Exposure, FLE), on each day of the time horizon, all forecasted cash inflows and outflows are netted and carried forward to the next day's FLE. In practice, the FLE can go up and down from day to day and thus the

[3] The HLA are naturally positive numbers; the cash outflows however need to bear in this context also a '+' sign because otherwise the left side of the inequality which has to be >1, would be negative.

[4] This does however not imply that the bank's nostro account with the central bank is necessarily equal to zero.

minimum balance will not necessarily occur on the last day. Contrarily, in the denominator of the LCR the maturing cash flows are summed in a way (outflows – min{inflows; 75% of outflows}) which enforces that the resulting netflows are outflows. Consequently the forecasted nostro balance descends monotonously until on the last day of the time horizon the worst balance appears.

The LCR's numerator consists of those hypothetical inflows, which stem from an assumed liquification of the HLA assets within 30 days. It is unclear how fast the assets are liquidised as the model specifies only what happens on the last day. Because we do not know what happens inside the time horizon, it is left unclear if the inequality in actual fact holds during the time horizon, and thus if the liquidity generating ability of the bank exceeds its forecasted cash needs on every day.[5]

1.2.6 Static run-off view - but hypothetical transactions

Only existing assets or liabilities are considered when forecasting the cash flows for the LCR; not yet existing liabilities or assets are not regarded. To determine the counterbalancing cash inflows, no explicit assumption about the repoability and/or saleability of the HLA is made. But how can an asset be turned into cash without selling or repoing it?

Assets (liabilities) which have been generated e.g. yesterday and will only be paid (received) tomorrow will create 'future' outflows (inflows) from today's perspective; there is however no such concept of 'forward' transactions in the LCR.

1.3 The Forward LCR

Assume the manager appointed to steer the bank's LCR has today successfully kept the LCR above 100% (or above a hurdle rate set by the bank's management) and reported this to the regulator. Basel III requires reporting on a monthly basis only; but in order to steer already today the LCR that will be reported in 30 days, the LCR-manager needs to be able to forecast now its value then. In a first approach, the Forward LCR is calculated with the assets and liabilities, as they exist now – without any assumptions about new future assets or liabilities.

We firstly formalize the calculation of the 'normal' LCR as it is performed today (t_0) for 30 days in the future. Next we extend its calculation to flexible periods (t_Y, to t_Z) in the future.

1.3.1 Normal and Forward HLA

We calculate in t_0 the 'normal' HLA(t_0):

- the HLA is constituted by the assets A_1, A_2, ...,A_N from the bank's balance sheet.

[5] In the Basel III Liquidity Framework we find "... banks and supervisors are also expected to be aware of any potential mismatches within the 30-day period and ensure that sufficient liquid assets are available to meet any cashflow gaps throughout the period" (*Basel Committee on Banking Supervision, Dec-2010, S. 3-4)*, without explicitly explaining how this should be implemented by the banks.

- today (t_0) a market value $m(t_0;A_n)$ and a haircut $h(t_0;A_n)$ exist for each individual asset A_n,

An individual asset's assumed liquification value equates as $a_n = A_n \times [m(t_0;A_n)-h(t_0;A_n)]$;
and all assumed liquification values a_n sum up to the $HLA(t_0) := a_1+a_2+ \ldots +a_N$.

If we calculate the HLA instead at a future day t_Y, the constituting assets do not change, but some of them will have already matured. By introducing liquification values a^*_j which are set to zero, if the asset has already matured before t_Y, the Forward $HLA(t_Y)$ equates to
$HLA(t_Y) := a^*_1+a^*_2+ \ldots +a^*_n$.

1.3.2 Normal and Forward TNCO

If the bank's balance sheet is constituted of assets A_{N+1}, A_{N+2}, ..., A_{N+M} (which are not of HLA type) and liabilities L_1, L_2, ..., L_K, we consider for the calculation of the 'normal' $TNCO(t_0)$ as of today (t_0) only those asset respectively liabilities which mature until t_0+30^d.
Let α_{N+1}, α_{N+2}, ..., α_{N+M} be the redemption values of the assets and λ_1, λ_2, ..., λ_K of the liabilities; we define for a future day t_X ($\leq t_0+30^d$):

- A_X as the sum of all redemption values α of the above assets that mature at t_X
- L_X as the sum of all redemption values λ of the above liabilities that mature at t_X.

Applying the 75% rule of the LCR gives the (negative) net cash flow in t_X as:
$N_X := -L_X + \min\{A_X;75\% \times L_X\}$.[6]

Consequently, with $t_X = 0, 1, 2, \ldots, 30$, the TNCO as of t_0 equates to
$TNCO(t_0) := N_0+N_1+ \ldots +N_{30}$.

If we extend the calculation of the A_X, L_X, and N_X until $t_X = t_0+30^d$ we get the
Forward $TNCO(t_Y) = N_Y+N_{Y+1}+ \ldots +N_{Y+30}$.

1.3.3 Normal and Forward LCR

The result is:

- $LCR(t_0) = HLA(t_0)/TNCO(t_0)$ - the normal LCR, calculated in t_0 (for the period until t_{30}) and
- $LCR(t_Y) = HLA(t_Y)/TNCO(t_Y)$ - the Forward LCR, calculated in t_Y (for the period until t_{Y+30}).

1.3.4 Degrees of Freedom to Simulate the Forward LCR

If we simulate in t_X the Forward LCR, we need to estimate the forward market value $m(t_Y;A_m)$ and the forward haircut $h(t_Y;A_m)$ as they will prevail in in t_Y. The assumed liquification value will then be equated as $a_n = A_n \times [m(t_Y;A_m)-h(t_Y;A_m)]$. The forward market value can be derived,

[6] Strictly speaking, we have to separate the cash flows from the off balance sheet transactions into inflows and outflows and add them to A_X respectively to L_X before equating N_X.

using the well-known methods from market and credit risk management. The forward haircut depends also on the future credit quality of the asset, but can also change with the sentiment of markets. If potential counterparties that would buy or in-repo the asset have little liquidity themselves (or are at least insecure about their upcoming liquidity situation), the haircut could significantly rise independently from a deterioration of the asset's credit quality[7].

The simulation of redemption values α_n for assets depends also on forward credit and market risk parameters. The redemption values λ_k for liabilities can on the one hand be regarded as fixed (for deposits); on the other hand they might be also parameterized as the bank could buy back its own debt.

What we have so far assumed to be unchanged is the composition of the balance sheet with existing assets and liabilities.

1.4 The Future LCR*

1.4.1 The Downsides of the Forward HLA

The calculation of the Forward LCR equates the 'normal' LCR as it would be calculated on a future day t_Y but with the bank's balance sheet, as it exists today; that is: the bank's assets and liabilities mature as contractually scheduled, neither a new asset or liability is acquired nor an existing asset is sold until t_Y.

The downside of the Forward LCR, although technically correct, is that in practice, the bank will replace maturing and acquire new assets and liabilities[8] – which makes the Forward LCR unusable as a prediction of the 'real' LCR that will prevail in t_Y.

1.4.2 Simulating A More Realistic Forecast for the 'Real' LCR

In order to better forecast the 'real' LCR in t_Y, we need to simulate the bank's future balance sheet evolution between t_0 and t_Y as realistic as possible.
We can for example conjecture:

- new HLA assets $A^{\#}_1$, $A^{\#}_2$, ...,$A^{\#}_K$ will replace some of the maturing HLA assets
- the according refinancing transactions need to be regarded as well: $L^{\#}_1$, $L^{\#}_2$, ...,$L^{\#}_K$
- new assets $A^{\dagger}_1$, $A^{\dagger}_2$, ...,$A^{\dagger}_P$ will replace some of the maturing other assets
- new liabilities $L^{\dagger}_1$, $L^{\dagger}_2$, ...,$L^{\dagger}_Q$ will replace some of the maturing liabilities
- other additional assets or liabilities might be acquired by the bank.

[7] For this considerations compare: *The Liquifiable Index (LiX) of an Asset - 2012-04-06*, by Darren Brooke, Matthias Küstner & Robert Fiedler; http://www.liqrisk.com/lix/.

[8] Only a dying bank will not generate any new assets or liabilities. But even a bank in an order liquification procedure will need to ‚square' its cash nostro with the central bank.

The Future HLA* and TNCO* are calculated with the same methods as the Forward HLA_Y and $TNC0_Y$, but with the appropriate set of new future assets and liabilities in t_Y.

The Future LCR* = HLA*/TNCO* is a more realistic forecast of the LCR as it will prevail in a future day t_Y, assuming a development of the balance sheet as specified above.

1.4.3 Constraints of the Simulation

The question arises if the above acquisition of assets and liabilities can be freely simulated or if some restrictions have to be regarded:

- The first constraint of the proposed simulation is, that the sum of all 'living' assets and liabilities need to match at any point of the simulation's time horizon.
- Note that in the simple buy-and-hold simulation as it is used for the Forward LCR above, it is very unlikely that the amounts of assets and liabilities maturing in t_Y will be identical: therefore the bank's balance sheet will not balance in t_Y – which is impossible in reality.
- From the above follows, that if the sum of assets does not equal the sum of liabilities on one day, the bank needs to acquire the appropriate liabilities or assets to equipoise the balance sheet. If there are more liabilities than assets, we can assume that the bank can give a loan, or at least deposit the cash surplus at its central bank nostro account – but can this be reversed?
- Classical asset driven banks will acquire the asset first and then try find appropriate refinancing – which can go wrong, as we learned in 2007 and 2008.
- Liability driven banks, a small minority, have bigger headroom to model their balance sheets, although the inherent risk is that they can only place their funds in assets with inappropriate return and/or risk characteristics.

1.5 Conclusion

The Forward LCR is a technically consistent extrapolation of the Normal LCR into the future. It is however in practice not a suitable instrument, as it ignores the inevitable change of a bank's balance sheet in the future. The Future LCR gives a much better forecast how the bank's LCR will equate – if the renewal assumptions for the balance sheet have been set up appropriately.

If the bank decides to set up a Forward LCR, it should consider if it would need to restrict the outcomes of the underlying balance sheet simulations or if it could already apply them for an economic simulation of funding liquidity risk.