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knowledge > topics in financial modeling

FOR MODELERS

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Cash flow financial modeling 101 for legacy commercial banking

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Basic theory + models

You're an all-round cash flow financial modeler with decent experience in modeling non-financial companies

And, who could have guessed, banking is your next project!

You still have a little time to get yourself acquainted with the basics of modeling commercial banks

But where to start?..

If it's you, look no further — this tutorial article with its attached Excel models will do the trick

I'll get you covered with the essentials of banking and guide you through the steps to complete a simple, yet fully functional commercial banking model

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Contents

Acknowledgements

I'm grateful to Glenn Schepens for helpful clarifications regarding [4] and my banking clients for awesome projects.

Executive summary

- Banking business is way different from manufacturing, merchandising, or services in two main ways. First, commercial banks don't buy, sell, or produce goods or services. Second, they are tightly regulated.
- Banks act as go-betweens by taking deposits from those with excess of money, and giving loans to those who need cash. Loans are risky, and thus depositors need protection.
- Most national banking regulations stem from the so called "Basel Standards" — international supervisory frameworks and guidelines for bank capital, liquidity, and funding. The current one is generally "Basel III."
- Basel III regulation places certain restrictions on bank's balance sheet. It does so by obligating banks to maintain the levels of several balance sheet-based ratios above predetermined floors.
- In a nutshell, Basel III supervises bank's capital (on risk-based and non-risk based grounds), and liquidity (on short- and mid-term bases).
- The premise of regulation is simple. Capital: "have enough of it!" (with respect to the assets). Liquidity: "have enough of it!" (relative to the deposits). With Basel III, this simple idea has rather cumbersome and meticulous implementation, that needs to be somehow simplified for the purposes of cash flow modeling.
- To correctly model a commercial bank's cash flows, you need to (a) set up a proper 3-way projection engine, and (b) ensure compliance with all regulations at all times.
- Steps to complete a model are:
    1) Start from balance sheet: project key assets and liabilities.
    2) Project interest income and expense, operating expenses and taxes. Calculate net income and link it to the capital section of the balance sheet.
    3) Link balance sheet changes and net income to calculate cash flows. Link cash change back to the balance sheet to close the loop.
    4) Incorporate credit risk accounting module.
    5) Use in-house or third-party proxy models to calculate regulatory ratios. Set up a warning system to make sure all requirements are met at all times.
    6) Refine and reinforce your model as needed.
- The model you'll arrive at in the end of this tutorial will be a simple yet capable tool for capturing key interrelations in the commercial bank's cash flow analysis. You'll be able to build on it in any way desired, like valuation, FP&A, and more, as your project involves.

Introduction

Deposit: you have money but you live like you don't

Loan: you don't have money but you live like you do

conventional wisdom

Commercial banking as a business is very specific. It's different from standard manufacturing, or merchandising, or services. Thus if you're a modeler with background in modeling mainly manufacturing companies (as was me back in the day), and banking model is your next project, you need to grasp the specifics of banking before diving in. I had to do that the hard way. This tutorial article will help you do it much more efficiently. For the avoidance of misunderstanding: we talk only about *cash flow* modeling here.

As yet, there are very good resources for cash flow modelers out there. You can find really good tutorials on operational modeling of general manufacturing companies, oil and gas companies, infrastructure objects, etc. However if you turn your attention to financial companies, the public domain won't have much to offer.

Antill et al. [1] wrote a good book on general company valuation in 2008.[1] One part of it is devoted to a banking analysis. Then, in 2014, Massari et al. [2] published a book aimed specifically at the valuation of financial companies — and commercial banks, among others. The good thing about these two sources is they have accompanying Excel workbooks with banking valuation models. Recently, the banking valuation topic was also covered in Damodaran-induced article [6], where one of Aswath's padawans performed a comprehensive valuation of some Indonesian bank explaining every step of it and with some diving into the theory along the way. The underlying xlsx valuation books were not provided, sadly.

The best source of banking modeling I found to date is the *Breaking Into Wall Street*'s freemium course on banking valuation, [7]. It provides a step-by-step tutorial on building IB-style banking valuation models. If you want to get into every aspect of Wall Street's banking valuation modeling, this is probably your best bet.

Finally, if you need to get deeper understanding of the current banking regulation and risk management, my advice is to take a look at Dill [5]. The regulatory part of this article has adopted much of the material from that book.

For banking modeling learners, the above materials have, however, two notable drawbacks. First is the lack of quality underlying Excel models. Even when it's not the case (like in [1] and [2]), the included models fall behind the current state of good modeling practice. Only [7] represents some second-best exception. It's very in the spirit of IB models — detailed, comprehensive, and presentation-oriented. It's good, but not good enough for our purposes. Especially if you just start learning banking modeling.

Second, all those sources prioritize *valuation* rather than *modeling* as such. Modeling is just used there as a tool to perform valuation, and thus the former is not being adequately addressed.

Hence this tutorial. My goal is to provide you with fundamentals of operating modeling for banking in line with good modeling practices. I aim to get something up and running quickly and cheaply. In a field like banking, there are lots of details, and sometimes these details get in the way of understanding the concepts. To get around this problem, I'm going to concentrate on the big picture. It will be easy for you to find the details elsewhere.

You will learn how to build a correct fully-integrated commercial banking model meeting basic regulatory requirements. This is not a black-belt course in banking modeling, though, and I won't dive deep into detail (refer to the above resources if you need to), just plain modeling mechanics as far as commercial banking is concerned. Batteries included — all underlying Excel files are part of this article, and I encourage you to look into them while studying the material below.

It's worth noting that this article covers only *commercial* type of banking, i. e. a legacy financial institution that only take deposits and makes loans. The business logic of other types of banks — investment banks, broker-dealers, neobanks, etc. — can differ from the one presented here.

Now, what's the best way to use this tutorial? Depends on your circumstances. I would expect a number of scenarios.

If you're really short of time or you feel desperate, *you can skip reading this article altogether* and rush directly to the models. They are reasonably well-annotated, and if you understand at least the basics of Basel III regulation yet, you should do just fine. The highest bang for the buck, utmost efficiency.

If you still understand Basel, but you'd like to get some guidance into the modeling mechanics, another viable approach would be reading only the modeling section.

Finally, you can read the article if full except the math part. The latter's aimed at gaining a better understanding of the crux of the Basel III regulations, so you can get a feeling for how it all fits together. And thus, it can be skipped upon first reading, or completely, for that matter.

It's all here, so let's get started! Modeling is all about logic. If you want to model banking, you better understand what it is and how it works. So if you do understand basic commercial banking, you can skip the next section and flip directly to Banking cash flow financial models. Otherwise, let's begin. ELI5, huh? Here you go.

Banking 101

Background

As a generalist modeler, you probably understand the economics of a XX century industrial corporation pretty well. Buy inventory and fixed assets, convert them into products, and sell them to your customers, either end users or other corporations. Strive to take control over your markets and resources. Do your best to keep high enough positive gross margin. Finance your operations with various forms of debt, equity, or hybrid instruments. In such a company, all operations can be relatively easily decomposed into operating, investment, and financing activities. Quite neat.

But banking? That's a different story. First, its business is offbeat. Banks don't buy or sell any goods... well, at least physical ones. Instead, they act as intermediaries by taking deposits from those with excess money, and issuing loans to those individuals and corporates who need it. This is the simplest form of banking possible. Besides, all banks invest some of the money they gathered into securities.

Thus, banking operations cannot be easily divided into either operating or financial. They are fused together: money is both a raw material and financing, all at the same time. Figure 1 exhibits a normalized balance sheet of a hypothetical average US bank in 2022.[2] The latter invests about half of its money into loans, over fourth of it into securities, and finances c. 80% of those operations with deposits. Note that the presented balance structure is quite volatile across countries.

Second, banking business is tightly regulated — much stricter than an average industrial corporation. Let's see why.

As we've seen, banks collect money from depositors, and then lend it to those who need to borrow. Lending money is inherently risky: there could be no guarantee that 100% of if is gonna pay back. Some money can and will be lost along the way: some borrowers are always unable to meet at least some of their obligations, or bank's other assets fall in value. Thus the governments believe there must be a mechanism to guarantee the depositors that they would recover at least a fraction of their investments, under any circumstances banks may face.

Take a moment to reflect on this. On one hand, a bank's key sources of external financing — deposits and subordinated loans — are relatively stable. No matter how good or bad banking business is, it has to pay the fixed price for what funds it uses. This means the liability part of its balance sheet is generally fixed.

On the other hand, bank's assets — like loans, securities, or cash — all have different risk-return profiles. Cash is most liquid and least risky, venture loans are the exact opposite. The values of the assets can be highly volatile. It can go up if say the market value of securities portfolio increases. In most cases it goes down because of unexpected (or expected, as the case may be) credit losses. So total value of a bank's assets goes down as well.

So here's what we have. External liabilities are fixed, while assets are variable. How

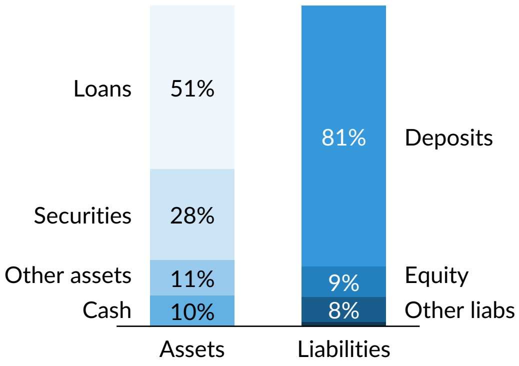

Fig. 1 Balance structure of an average US commercial bank (Q4 2022)

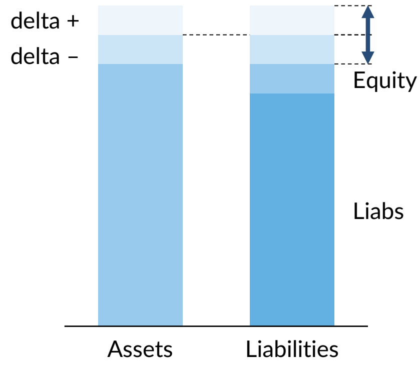

Fig. 2 Equity cushion at work: any small change in assets is reflected directly in capital

could depositors be sure they will recover what they lent to a bank if a bank's assets diminish in value? That is what bank's capital is for. It works like a safety cushion, or a buffer, or a shock absorber, by absorbing at least part of the losses and protecting the interests of depositors (Figure 2). If the value of assets goes up relative to the value of liabilities, it results in capital increase. If it goes down, the losses consume and and destroy capital. So, if some small enough (less than capital, technically) amount of money from bank's asset operations is lost, the loss will be covered by bank's capital and the depositors will feel no harm. Not a bad idea, I think.

But the bankers apparently think different. It depends of course on "how much capital is enough?" thing. I believe by now you start to suspect that the "optimal" level of bank capital is a controversial topic. Indeed it is — for decades if not centuries it's where the main battles take place. And it stems from the core conflict of interests between bank's shareholders and its regulators. The first, naturally, want the best return on capital. They want the highest ROE, i. e. net income per dollar of invested capital:

$$\text{ROE} = \frac{\text{Net Income}}{\text{Capital}},$$

which means less capital, other things being equal. On the contrary, regulators want capital to cover as much bank's risky assets as possible (we will discuss what "risky" actually means on page 17). So they like to see the *capital adequacy ratio* —

$$\text{CAR} = \frac{\text{Capital}}{\text{Risky assets}} \tag{1}$$

as high as possible. 100%, preferably. This would mean capital covers 100% of risky assets, and a bank can practically lend its own funds only — see you later, deposits. This is not practically possible, though, because the cost of equity can't possibly be lower than the return on credit assets — and thus a banking business would be systematically loosing money. So, it's clearly below 100%, but below by how much exactly?

This is the key question of banking risk management and regulation debates. Nobody talks about "90," "50," or even "20%." The debates are around numbers like "15 vs 8%."

The second question is that of *liquidity*. This is a measure against the "bank runs," or liquidity risk. If a bank's major assets are long-term, what happens if liability holders of a bank want to suddenly cash out? Nothing pleasant. Thus a bank is required to hold a certain fraction of its exposures as liquid assets like cash and deposits with central bank. So while capital adequacy is about architecture of the liabilities side of banking balance sheet, liquidity regulation is about the structure of its asset side.

The Basel Committee on Banking Supervision ("BCBS") as an affiliate of Bank for International Settlements ("BIS," the "central bank of central banks") formulates and promotes the so called Basel Standards (aka "the Standards," or "Basel Accords") — broad voluntary supervisory frameworks and guidelines for bank capital, liquidity and funding. The members of BCBS — 28 countries as of today — are supposed, yet not obliged, to implement the Standards through their domestic regulation. It started in 1988 with "Basel I" set of requirements, developed into "Basel II" in 2004, and finally into "Basel III" in 2010. Its implementation is ongoing. It was extended repeatedly and was expected to finally became effective in January this year. The current status is unclear, as the latest status report was presented in September 2022.[3] Without letting anyone catching their breath, "Basel IV" is already making its way... The material in this article is based on Basel III. Keep in mind though that Basel accords are just *frameworks* — and thus, national regulations for a particular bank you might be analyzing may differ for US, UK, EU, etc. Since this is an introductory tutorial, I'll clearly not enter into country-specific details here. Also, beware that Basel regulation is a fast-evolving stuff, and some of the things I tell you will change in the future — maybe even by the time you read this!

Summing up. From a regulator's perspective, a bank faces two key risks: the need to absorb losses and the need to meet urgent obligations. Capital adequacy concept aims to mitigate the former, while the liquidity regulation deals with the latter. We'll next take a closer look at banking regulation as far as modeling is concerned. If you have already grasped the concepts of capital and liquidity regulations, feel free to skip to the modeling section.

Regulation

So how does Basel regulation work in practice? Relatively straightforward. Essentially, Basel Accords require a bank to maintain at all times the value of certain ratios above some minimum levels. If some ratio comes close to its authorized floor, a bank is required to take proper actions to restore its value by either selling risky assets or raising more capital. As simple as that!

I noted above that *capital adequacy* and *liquidity* are key areas of banking regulation that are directly related to modeling. If you are anything like me, you prefer to use the modeling language to express any relationships you deal with that include more than two variables. Thus before considering all those regulations separately in detail, we might as well start by building a simple and stylized framework of a bank's balance sheet. This is gonna help you gain a bigger picture and understanding of what's going on with the regulations on a high level. Get your nose into the inner workings of it, so to speak.

That said, the rest of this section is optional. If you don't feel like getting into formulae, you can fast forward safely to the next section.

A simple banking balance sheet model

Below I follow a framework presented by Cecchetti et al. [3]. It considers a very simplified version of banking balance sheet to help grasp key ideas of regulation.

Basel III regulation is all about putting constraints on the composition of a bank's balance sheet. It has two blocks each consisting of two parts. The first block regulates capital, and the second one addresses liquidity (Figure 3). Why those two? For the reasons we discussed above — because possible losses can be absorbed by either current liquid assets or the capital.

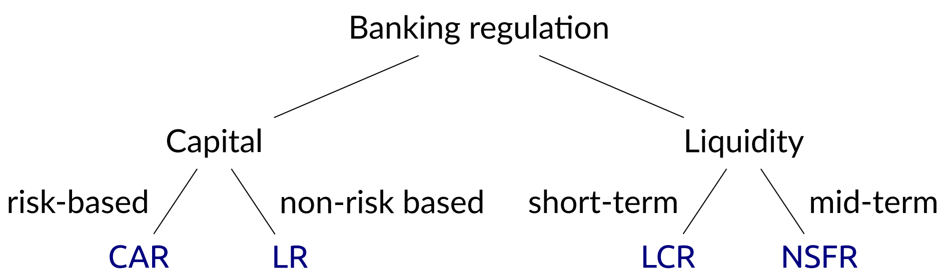

Fig. 3 The bottom line of Basel III banking regulation

Capital regulation block includes two requirements that impose restrictions on the level of capital. It simply says that equity must be greater than a fraction of the sum of assets — either simple sum or a sum of assets weighted by their riskiness. The risk-weighted ratio forces banks with riskier assets to maintain more capital. It's called a "capital adequacy ratio" (CAR), or a family of capital adequacy ratios, to be precise. The second, an unweighted one, ties the level of capital to the overall size of bank's assets, including both on- and off-balance sheet items. It's called a "leverage ratio" (LR).

Liquidity regulation is built on the two ratios as well, both intended to ensure a bank can withstand funding reductions like deposit withdrawals or liquidity demands arising from off-balance sheet activities. The first one, "liquidity coverage ratio" (LCR), aims to maintain a bank's short-term — a month-length — liquidity. It says that a weighted, in a certain way, sum of assets must be greater than a weighted sum of liabilities. The second one, "net stable funding ratio" (NSFR), seeks to secure the stability of a bank's funding over a more extended period — a year. It actually reverses LCR, stating that a weighted sum of liabilities must be greater than a weighted sum of assets.

So what are interrelationships between all the above ratios? A simple balance sheet model will help you elucidate them.

Consider a stylized banking balance sheet. On the asset side, we see a pool of relatively safe, high-quality liquid assets, denoted as R, and risky assets, A. In addition, a bank has some off-balance sheet assets, which we symbolize as $OBSA$. These items are converted to the same units as other on-balance sheet assets. So we have risky assets A with A_i being the i-th one, $i = 1, \dots, n$, and a number of off-balance sheet items $OBSA$ with $OBSA_j$ being the j-th one, $j = 1, \dots, q$.

Further, different risky assets have different risk profiles, so to make risky assets "comparable," they are weighted according to their riskiness. Thus w_i^A stands for the risk weight associated with asset A_i. Similarly, w_j^O defines risk weight for $OBSA_j$.

On the liabilities side, there are three blocks. One is a group of "runnable" items which we think of collectively as "deposits" and denote their s's item by D_s, where $s = 1, \dots, p$. Second block consists of more stable and longer-term funding items which we code-name as "bonds" and denote by B_k its k's element, $k = 1, \dots, m$. The last block is the residual part, the capital K.

With these notations the "extended" balance sheet that includes also off-balance sheet assets is exhibited in Table 1.

	Assets	Liabilities
On-balance sheet	R	D_1
	A_1	$\vdots$
	$\vdots$	D_p
	A_n	B_1
		$\vdots$
		B_m
		K
Off-balance sheet	$OBSA_1$	
	$\vdots$	
	$OBSA_q$	

Tab. 1 Stylized "extended" banking balance sheet, expanded view

A lot of variables makes it problematic to work with. Let's aggregate them to make the problem definition easier to grasp:

$D = \sum_s D_s$, total deposits;

$B = \sum_k B_k$, total long-term liabilities;

$A = \sum_i A_i$, total on-balance sheet risky assets;

$L = \sum_i w_i^A \cdot A_i$, total on-balance sheet risk-weighted assets;

$OBSA = \sum_j OBSA_j$, total off-balance sheet assets; and

$OA = A - L$, other assets (under a reasonable assumption that $OA \geq 0$).

With some simplification, the above notations allow to rewrite the balance sheet from Table 1 in the collapsed form exhibited in Table 2.

	Assets	Liabilities
On-balance sheet	R	D
	L	B
	OA	K
Off-balance sheet	$OBSA$	

Tab. 2 Stylized "extended" banking balance sheet, collapsed view

Time to formulate. I start with handling regulations in original notations, and then try and convolute those into aggregates.

Let's begin with capital, or equity. A family of CARs requires that certain tiers of capital K must be no less than a certain fraction of the sum of risk-weighted on-balance sheet risky assets A_i and off-balance sheet assets $OBSA_j$:

$$\text{CAR} = \frac{K}{\sum_i w_i^A \cdot A_i + \sum_j w_j^O \cdot OBSA_j} \geq \gamma, \tag{2}$$

where γ is the prescribed CAR floor, a number like 10%.

LR follows a similar logic, but applies it to a simple sum of all assets. Thus it can be expressed directly in terms of aggregates:

$$\text{LR} = \frac{K}{R + A + OBSA} \geq \delta, \tag{3}$$

where δ is the demanded LR floor, a number like 5%.

That's it for capital. Now let's talk liquidity. A short-term measure, LCR, requires that a bank holds "high-quality liquid assets," R, in an amount to ensure coverage of outflows in a certain short-term stress scenario. It appreciates both runnable deposit liabilities and contingent assets. Assuming that l_s^D and l_j^O are run-off rates on liabilities D_s and off-balance sheet assets $OBSA_j$, the regulation can be written as

$$\text{LCR} = \frac{R}{\sum_s l_s^D \cdot D_s + \sum_j l_j^O \cdot OBSA_j} \geq \sigma, \tag{4}$$

where σ is the required LCR floor, a number like 100%.

A mid-term measure, NSFR, forces "*available* stable (mid-term) funding" to cover some portion of "*required* stable (mid-term) funding." The amount of available stable funding is calculated as a sum of weighted average of deposits D_s and bonds B_k, and capital K (a plain, non-weighted version of it). Similarly, the value of required stable funding is a weighted sum of assets A_i. For both metrics, weights are provided by

Basel Accords. Let's denote them as a_k^B, a_s^D, and f_i for bonds, deposits, and assets, respectively. Thus we can write

$$\text{NSFR} = \frac{\sum_k a_k^B \cdot B_k + \sum_s a_s^D \cdot D_s + K}{\sum_i f_i \cdot A_i} \geq \tau, \tag{5}$$

where τ is the required NSFR floor, a number like 100%.

That's about all. The above inequalities 2–5 fully define Basel III regulation. They are just enough to sense the idea. However they still look quite cumbersome, so let's try and simplify them even further.

Consider the denominator of formula 2 for CAR. Its first term equals L by definition. Now let's define

$$\psi \equiv \frac{\sum_j w_j^O \cdot OBSA_j}{OBSA},$$

the average risk weight for off-balance sheet assets. With these, inequality 2 can be simplified to

$$(\text{CAR}) \qquad K \geq \gamma\,(L + \psi OBSA)\,. \tag{6}$$

Pretty sweet. Next, LR inequality 3 is already there, I just rewrite it here in the line form:

$$(\text{LR}) \qquad K \geq \delta\,(R + A + OBSA)\,. \tag{7}$$

So far so good. Averaging gives quite sensible simplification, so we might as well apply it for formulae 4 and 5. Let's establish

$$\alpha \equiv \frac{\sum_s l_s^D \cdot D_s}{D} \qquad \text{and} \qquad \omega \equiv \frac{\sum_j l_j^O \cdot OBSA_j}{OBSA},$$

average run-off rates on deposits and off-balance sheet assets, correspondingly. Then LCR inequality 4 simplifies to

$$(\text{LCR}) \qquad R \geq \sigma\,(\alpha D + \omega OBSA)\,. \tag{8}$$

Similarly, by introducing average "available" and "required" NSFR factors

$$\eta^B \equiv \frac{\sum_k a_k^B \cdot B_k}{B}, \qquad \eta^D \equiv \frac{\sum_s a_s^D \cdot D_s}{D}, \qquad \beta \equiv \frac{\sum_i f_i \cdot A_i}{A},$$

inequality 5 rewrites to

$$(\text{NSFR}) \qquad \eta^B B + \eta^D D + K \geq \beta\tau A. \tag{9}$$

Not bad so far, but we can do better. Now, taking the path of further simplification, assume that risk-weighted assets L and off-balance sheet assets $OBSA$ are proportional to the level of on-balance sheet risky assets A:

$$L = \phi A \quad \text{and} \quad OBSA = \theta A. \tag{10}$$

With these, inequalities 6–8 further reduce to

$$\begin{aligned}
&(\text{CAR}) \qquad K \geq \gamma\,(\phi + \psi\theta)\,A, && (11)\\
&(\text{LR}) \qquad K \geq \delta\,[R + (1+\theta)\,A]\,, && (12)\\
&(\text{LCR}) \qquad R \geq \sigma\,(\alpha D + \omega\theta A)\,. && (13)
\end{aligned}$$

It might look like the end of the journey, but it's not. There are two more steps left to make it look even neater.

First, let's normalize the level of capital by setting $K = 1$. This is equivalent to considering the remaining variables relative to capital, i. e. R/K instead of R, and A/K instead of A, etc. Thus, one variable less.

And second, let's use the balance sheet identity $R + A = B + D + 1$ to eliminate B from NSFR inequality 9.

Having done so, the above inequalities 9–13 simplify to the final set

$$\begin{aligned}
&(\text{CAR}) \qquad A \leq \frac{1}{\gamma\,(\phi + \psi\theta)}, && (14)\\
&(\text{LR}) \qquad A \leq \frac{1}{1+\theta}\left(\frac{1}{\delta} - R\right), && (15)\\
&(\text{LCR}) \qquad R \geq (\theta\sigma\omega)\,A + (\alpha\sigma)\,D, && (16)\\
&(\text{NSFR}) \qquad R \geq \left(\frac{\beta\tau}{\eta^B} - 1\right)A + \left(1 - \frac{\eta^D}{\eta^B}\right)D + \left(1 - \frac{1}{\eta^B}\right). && (17)
\end{aligned}$$

Bingo! Here it is — all Basel III regulations neatly compressed into four simple inequalities with only three aggregated variables. Worth taking a quick look.

First, four inequalities for three variables seem like an overkill. At least one of the four will most likely be non-binding. In other words, one of the four key regulations is probably redundant — nothing would have changed if it were omitted.

Second, if you compare CAR and LR inequalities, it's clear that if risk weights are sufficiently low, inequality 14 will always be satisfied as long as 15 is satisfied, and thus there's a good chance that 14 is also non-binding.

Similarly, take a closer look at inequalities that stem from LCR and NSFR. They suggest that liquid assets R will probably be constrained by either 16 or 17, but not by both of them together at the same time. Which is surprising if you remember that LCR and NSFR metrics are supposed to be *complementary*, rather than overlapping regulations.

I won't drill down any deeper here, but the take-home message from the above analysis is the essence of Basel III regulation: it places *two upper bounds on the level of risky assets a bank can have, and two lower bounds on the level of liquid assets a bank must hold.* That's it, neat and clear.

Okay, now as you got a taste of basic regulations, let's roll up the sleeves and move on to the nitty-gritty of it.

Capital adequacy requirements

Capital regulation is the main framework of Basel Accords. There are two types of regulatory capital metrics.

The first is a family of *capital adequacy ratios*, like the CAR in Equation 1 on page 8, with minimum requirements (floors) set for them. Banks are required to maintain a minimum amount of capital relative to risky assets. There's a number of capital adequacy ratios for a bank to maintain. All of them have the same denominator called *risk-weighted assets* (RWA) — total assets owned by a bank adjusted for their perceived riskiness. The numerators of capital adequacy ratios are measures of bank capital defined in tiers depending on their loss-absorbing capacity.

Second metric is a *leverage ratio*. It's similar to capital adequacy ratios, but the denominator is taken on a non-risk weighted basis. Thus it is reasonably easier to calculate and monitor. It also reinforces risk-based measures and restricts the build-up of on- and off-balance sheet leverage in a bank.

Let's start by looking at

Risk-based ratios

Capital tiers Capital is organized into categories, or *tiers*, depending on its ability to cover losses. There are two tiers with such descending ability — Tier 1 (T1), comprising Common Equity Tier 1 (CET1) and Additional Tier 1 (AT1), and Tier 2 (T2). T1 is a "going-concern" capital, meaning that relying on this class of capital to cover losses does not imply significant likelihood of a bank's bankruptcy. CET1 is the highest quality part of T1, as it absorbs losses immediately when they occur. Its main components are common shares, stock surplus, retained earnings, and other comprehensive income. AT1 does not qualify that high, but it still provides somewhat prompt loss absorption. In contrast, T2 is "gone-concern" capital in the sense that it starts absorbing losses when a bank's already close to default.

Total available regulatory capital, K, is the sum of the above elements:

$$\mathrm{K} = \underbrace{\mathrm{CET1} + \mathrm{AT1}}_{\mathrm{T1}} + \mathrm{T2}.$$

In a graphical form, the regulatory capital elements are depicted in Figure 4.

As I spoke earlier, banks are required to maintain specified minimum levels of CET1, T1, and K, with each level set as a percentage of RWA. The values of those floors, according to Basel III, are exhibited in Figure 5.[4] Besides, T2 cannot exceed T1. In addition to that, Basel III introduced two more regulatory metrics:[5]

- *Capital conservation buffer* (CCoB): tightening of CET1 and sitting on top of it's floor value, thus effectively increasing the latter. The floor value of CCoB is 2.5%

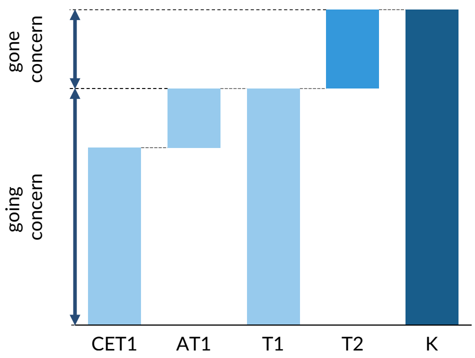

Fig. 4 Regulatory capital tiers (note: scale not meaningful)

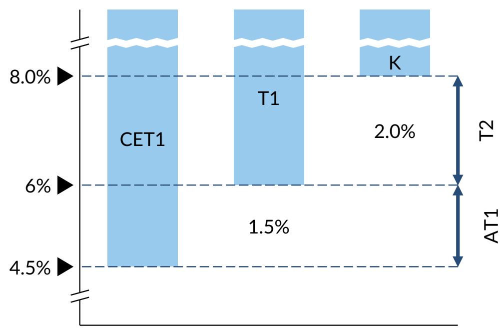

Fig. 5 Regulatory capital floor values as per Basel III

of RWA. So while CET1 floor is 4.5%, some restrictions start to already apply when it's below 7% — for example, limits on the amount of dividend and bonus payments a bank can make.

- *Countercyclical capital buffer* (CCyB): a measure designed to help counter pro-cyclicality in banking system. It sits on top of CCoB floor. Advised to be introduced in national economies if credit is expanding too rapidly, and switched off otherwise. The floor value is up to 2.5%, i. e. CET1 actual floor can be as high as 9.5% (4.5% + 2.5% + 2.5%), depending on applied policy. In EU, currently it ranges from 0% to 2.5% depending on the country.[6]

These two items are good to be aware about, but I won't embed them into the financial models we're gonna develop below.

What's in real life? Figure 6 exhibits live CET1 distribution across countries.[7] The median level is 16% with over 75% of countries having it above 14%.

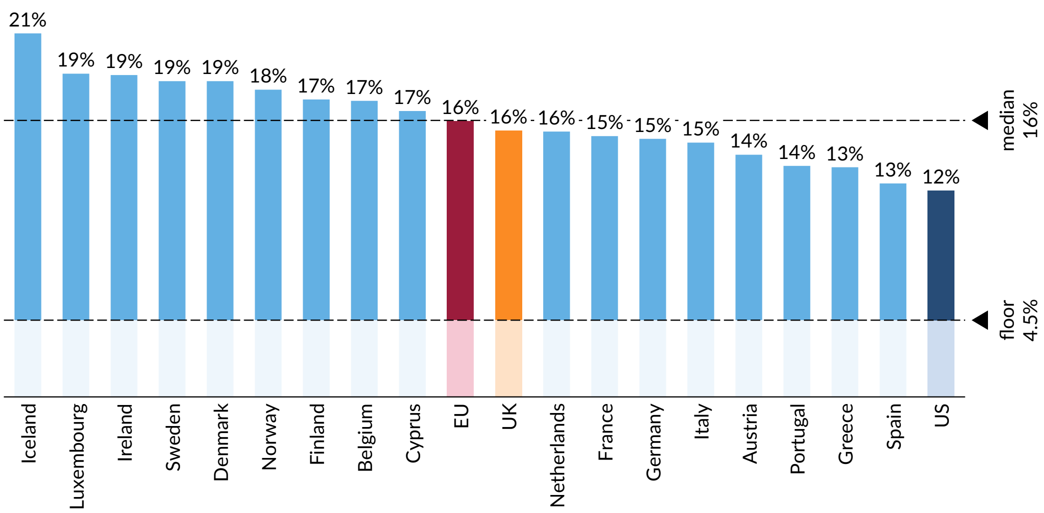

Fig. 6 CET1 ratio distribution across countries

So much for the numerator of an adequacy ratio. Let's finally see what RWA actually means.

Risk-weighted assets So as we say banks are required to maintain a minimum amount of capital based on a fraction of their "risky" assets. But what does "risky" really mean? Not all assets are created equal, as you may guess. Some have practically zero risk, like cash on hand, while others, like low-rated corporates, may entail very high risk. The higher the risk of an asset, the higher the probability of loss incurred by that asset. To handle this natural hierarchy of asset riskiness, all assets are categorized into several classes, and then each class is assigned a weight ranging from 0% for low-risk assets to as high as... deep inhale... 400% for such an asset as "speculative unlisted equity" — the higher the perceived riskiness of the asset class, the higher the weight.[8] For example, cash will have 0% weight, BB-rated bond will have 50%, while a corporate with rating below BB– will probably have 150% weight. You can find detailed description or RWA methodology (with outdated weights granularity, though) in Basel II document.[9]

To apply weights, assets' "exposures" are calculated. On-balance sheet items' exposures equal to their book values. Besides on-balance sheet assets, RWA also encompass off-balance sheets items like guarantees, financial standby letters of credit, forward agreements, warranties, etc. Before applying risk weighting to these, the user needs to obtain their "credit equivalent amounts." It's done by multiplying their contractual values by so called "credit conversion factors" (CCFs). The weighted sum of all assets' exposures constitutes RWA. In math terms,

$$\mathrm{RWA} = \sum_i w_i \cdot E_i, \tag{18}$$

where w_i is the risk weight mapped with asset i, and E_i is the exposure associated with that asset:

$$E_i = \begin{cases} \text{book value,} & \text{if item } i \text{ is an on-balance sheet asset} \\ \text{credit equivalent amount,} & \text{if item } i \text{ is an off-balance sheet asset.} \end{cases} \tag{19}$$

(Note: specific conversion rules behind second part of formula 19 are ~~very boring~~ beyond the scope of this article.)

Now, how do banks determine risk weights and match them with assets? By following one of the two broad methodologies — "standardized" approach (SA) or "internal ratings-based" (IRB) approach. Under the former, banks rely on ratings from external credit rating agencies to quantify asset risks. The weights are prescribed by the regulator. With the latter approach (called "advanced" set of approaches in US), banks use risk parameters estimated by themselves using certain statistical models. The first approach is simpler and is generally adopted by small-to-medium banks, while the second one is considered more robust and accurate. SA is available for all banks, while only large banks (over $250 bn of total assets) are eligible to IRB approach subject to supervisory approval.

Suddenly, this is not the end of the RWA story yet. Formulae 18 and 19 define what is known in Basel III as *credit risk RWA*. For small operation SA banks that are mostly loan makers, this is it. However, if SA or IRB bank is a "market risk bank" (gross trading assets and liabilities are at least 10% of total assets, or equal to at least $10 bn), then it has to add "market risk RWA" term to formula 18. Finally, IRB banks have yet another term in RWA formula, which is "operational risk RWA." So, a generalized formula for RWA looks like

$$\begin{aligned} \text{RWA} = {} & \text{Credit risk RWA} + \\ & + \text{Market risk RWA (for market risk banks)} + \\ & + \text{Operational risk RWA (for IRB banks).} \end{aligned} \tag{20}$$

The mechanics of IRB approach is even more cumbersome and I completely skip it here, as I won't use it in the coming models.

Now I accept all the above may look like a total mess if you are not used to it. The formulae above, and especially those I skipped, are highly complex, particularly for advanced banks. Formal calculation of RWA for a live bank is no kind of fun. Not only it is a profession in its own right. In fact, the accounting and IT systems to manage the RWA calculation and optimization can be extremely costly, especially for market risk IRB banks. IT solutions for compliance and risk management, typically sold by international consulting companies, are quite expensive. Calculating RWA is a complex process due to a combination of Basel III's highly granular approach to calculating risk-weighted capital charges and the complexity of some of the financial instruments in banks' portfolios. To ensure risk-return optimization, banks expend significant resources in managing their RWA to achieve the lowest amount of equity given their required return.

If you feel a little embarrassed, don't panic. The good news is that in the vast majority of cases you as a modeler won't have to bother knowing all the nitty-gritty of RWA calculation. If you model a bank as an outsider, you would want to base your judgment on the RWA values that banks disclose in their reports. As a startup or FP&A modeler, you'll need to discuss the risk-weighting assumptions with your clients, since they have specially trained people at their disposal that can do RWA workings like nobody's business. In the following models, I will stick to either a simplified credit risk only RWA calculation for SA non-market risk bank, or use some simple analytical approaches for approximation of bank's RWA.

In the meantime, to get your hands on it, consider a numerical example of an SA for a non-market risk bank in the attached file `Wb_1_RWA.xlsm`.

It exhibits the mechanics of calculating standardized credit risk RWA in a simplified imaginary situation (remember, all company-specific data in the example are just placeholders!). It's a very simplistic representation of how RWA calculations take place in the real-world scenarios. It's just a plain calculation engine, while real banking IT solutions offer more than that, i. e. optimization tools.

Before moving on, it's worth denoting one more ratio to remember, a *tangible common equity ratio* (TCR): tangible common equity (which is equal, in most cases, to CET1 capital) divided by the tangible portion of a bank's assets (total assets less goodwill and other intangibles). Though not part of Basel III, this metric is sometimes used internally as one of many capital adequacy indicators.

Non-risk based ratios

CARs that we inspected above all have RWA as their denominator. As you've just seen, its calculation is anything but easy. It would be nice to have some lighter backup ratio with less bulky computation burden. But more importantly, good capitalization does not necessarily imply low leverage. In 2008, Citigroup Inc. was one of the most capitalized US banks, and yet it received $476 bn from US government during bailout. Obviously capital adequacy is a good thing, but it's not enough. Some other measures need to be tracked to prevent buildup of excessive leverage in a bank.

With this motivation, Basel III introduced an extra measure of capital adequacy, an additional layer of protection that is not based on risk adjustments, a *leverage ratio*:

$$\text{LR} = \frac{\text{Capital measure}}{\text{Exposure measure}},$$

where Capital measure equals to T1, and Exposure measure includes non-risk weighted total consolidated on- and — for IRB banks — off-balance sheet assets. While the complex risk-weighting architecture of RWA metric opens a door for possible manipulations, the plain makeup of LR limits discretion and is thought to restrain over-leveraging of banks. Balance sheet assets deducted from T1 (like goodwill and other intangibles) may also be deducted from the Exposure measure to ensure consistency. The floor value is currently 3%. The details of LR framework can be found in the corresponding Basel III accord.[10] Depending on specific national regulations, not all banks are subject to leverage ratio requirements.

Figure 7 shows distribution of LR in EU, UK, and US, with a median at 6.2%.[11]

Okay, I hope the above gives you a good picture of capital adequacy issue. Let's now pay attention to the second cornerstone of Basel III regulation —

Liquidity requirements

As I noted above, if too much of banking assets are long-term and low-liquid, a bank is susceptible to a *liquidity risk*, i. e. the risk that it may be unable to meet its obligations as they become due. Banking assets are long-term (a project finance loan may have a 50 year tenor), while some deposits can be withdrawn at an immediate notice. So banks' ALM programs are facing a real challenge here. What are the appropriate metrics to track?

Historically, liquidity was monitored with the mechanism of *reserve requirements*. Reserves, as widely understood, is the total amount of cash held by commercial banks in the form of either cash on hand or the balance in their accounts with the central bank.

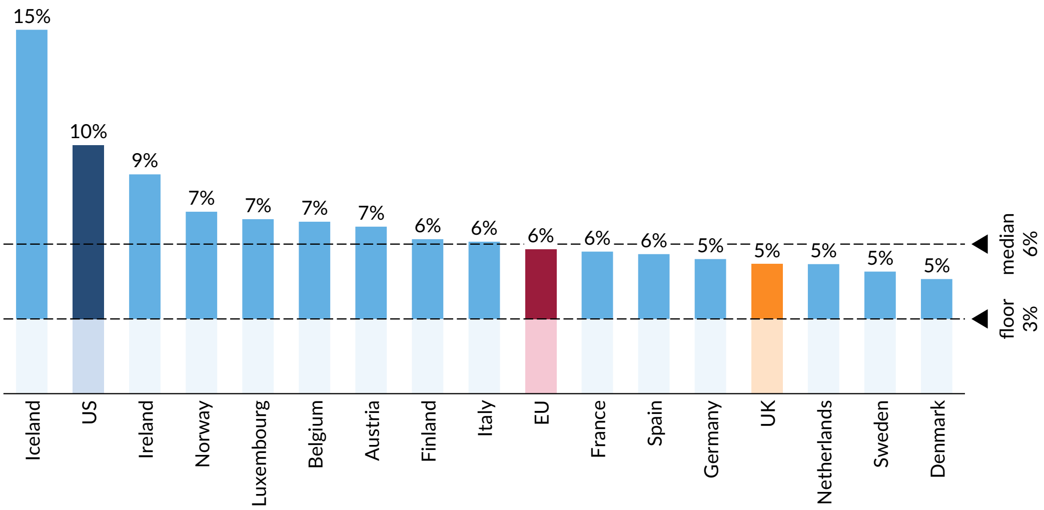

Fig. 7 LR values in UK, US, and across EU countries

Before Basel III, the relevant metric of reserves regulation was the minimum *cash reserve ratio* (CRR), or a bank's reserves in relation to its deposit liabilities:

$$\text{CRR} = \frac{\text{reserves}}{\text{deposit liabilities}}.$$

Nowadays, in many countries, CRR requirements are abandoned (though in many, they still exist).[12] Basel III Accords went further in determining the pertinent ratios to monitor. The framework laid down even more stringent rules, which effectively made classic CRR loose its relevance.

The modern approach is twofold. Two ratios are monitored, one for short- and another for longer term liquidity.

LCR

The first one is the *liquidity coverage ratio* (LCR), designed to ensure that a bank has sufficient liquidity to withstand a short-term stress in the financial markets.[13] It's a logical evolution of CRR. The ratio reads as follows:

$$\text{LCR} = \frac{\text{HQLA}}{\text{Net cash outflows for the next 30 days}}.$$

HQLA The numerator of LCR, HQLA, stands for "high-quality liquid assets," consisting of central bank reserves and government and corporate debt that can be converted easily and quickly into cash through sales. HQLA are supposed to have ability of converting into cash at little or no loss in value in private markets to survive an acute liquidity stress lasting up to one month.

Those liquid assets are divided into several categories. Level 1 assets can be included into HQLA without limit (up to 100% of HQLA), while Level 2 assets can only comprise up to 40% of total HQLA. Level 2 assets further divide into Level 2A assets subject to a 15% haircut, and Level 2B assets, subject to higher haircuts and totaling up to 15% of HQLA.

Level 1 assets are coins and banknotes, central bank reserves, and some marketable securities. Level 2A assets include some marketable securities, and some corporate debt securities and covered bonds. Level 2B assets comprise some residential MBS (25% haircut), some corporate debt securities (50% haircut), and some common equity shares (50% haircut).

Net cash outflows As LCR is calculated under the assumption of a “stress scenario,” Net cash outflows are calculated in an analytical way. It is assumed that assets and liabilities flow in, are run-off, or being drawn down at some pre-defined fixed rates (“factors”). Thus to get cash flow values, outstanding balances are multiplied by these rates, and then the resulting cash flows are netted. To discourage banks to rely solely on anticipated inflows to meet their liquidity requirement, and also to ensure a minimum level of HQLA holdings, the amount of inflows that can offset outflows is capped at 75% of total expected cash outflows. (It follows, among other things, that HQLA cannot be less than 25% of the total expected cash outflows.) Thus,

$$\begin{aligned}\text{Net cash outflows} = {} & \text{Exp. cash outflows} - \\ & - \min\left\{\text{Exp. cash inflows}, 0.75 \times \text{Exp. cash outflows}\right\}.\end{aligned} \tag{21}$$

Note that for the purpose of LCR calculation, liquid assets can be used either as HQLA or for cash inflows. Can the same asset be used for both? Clearly no. The idea behind LCR is that highly liquid assets are rapidly sold in case of emergency, so there’re no cash inflows associated with them, so no cash inflows on these assets are included in the denominator. Double counting items in the numerator and denominator is not allowed. Thus, if certain asset is included as part of HQLA, its associated cash inflows cannot also be counted as cash inflows for LCR purposes. Accordingly, all bank’s assets considered “liquid” by the corresponding Basel III accord are divided into HQLA-eligible ones (Level 1 and 2), and other assets that can generate cash inflows but are ineligible for HQLA.

A summary of the factors applied to each category can be found in the above-mentioned Basel III accord on LCR.

The floor value of LCR is currently 100%, though it’s admissible to be lower if a bank experiences actual financial distress. Hence normally LCR requires banks to hold a stock of HQLA at least as large as expected total net cash outflows for the next 30 calendar days under a stress scenario specified by a regulator.

Distribution of LCR in Europe is laid out in Figure 8.[14] The median level is 166%. Given the relative novelty of the indicator, data on LCR outside Europe is sparse as yet.

If you feel like getting into the nitty-gritty of it, see the sample calculation of LCR in the attached file `Wb_2_LCR.xlsm`. Before you do, remember one thing: this is a *hypothetical* calculation. In live banks it’s a little more complicated than that.

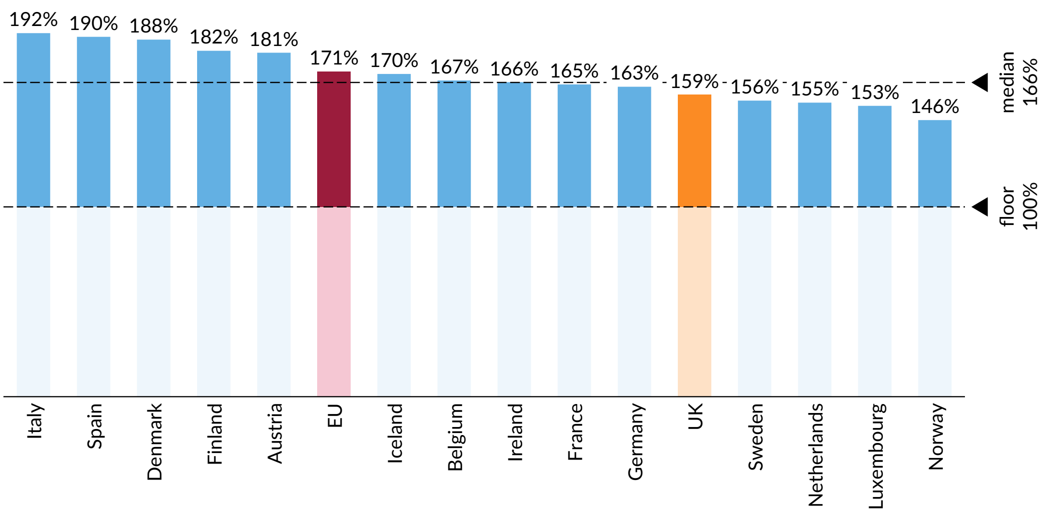

Fig. 8 LCR values in UK and across EU countries

OK, so LCR is monitored to promote short-term funding resilience. What about preventing impact from longer-term liquidity stresses? Meet the

NSFR

Net stable funding ratio (NSFR) was introduced in Basel III to promote funding stability and limit bank's over-reliance on short-term funding. Mandating high-quality liquidity for an extended period (i. e. holding HQLA over one month's worth) is expensive and counterproductive for a bank. Thus, the second ratio trades liquidity for stability. NSFR requires that banks maintain a sound funding structure over one year in relation to the composition of their assets and off-balance sheet activities. It reads as follows:

$$\text{NSFR} = \frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}},$$

where

- "Required amount of stable funding" aims to measure how much funding a bank may require within a one-year horizon. It's determined by weighting assets and off-balance sheet exposures according to their likelihood of still being on the balance sheet 12 months into the future. The corresponding "required stable funding" (RSF) factors are listed in the Tables 2 and 3 of the appropriate Basel III accord.[15] The assets and OBS exposures are multiplied by the corresponding RSF factors, and the resulting total renders the required amount of stable funding.

- "Available amount of stable funding" follows the same logic, just on the liabilities side. The associated "available stable funding" (ASF) factors are specified in the Table 1 of the above-mentioned Basel III accord.

The floor value is currently 100% and it must be maintained at all times. The structure of the ratio is similar to that of LCR. Still if delving into the LCR calculation above was not enough for you, you can take a look at the attached file `Wb_3_NSFR.xlsm` for a stylized calculation of NSFR.

The ratio is relatively new. No reliable data on actual NSFR distribution is available yet, to my knowledge.

The last thing to mention — depending on specific national regulations, not all banks are subject to LCR or NSFR requirements.

* * *

Woof! This wraps up the 101 commercial banking essentials. Equipped with the above starter knowledge of legacy banking and its regulation, let's get our hands dirty with the stuff I bothered to write this article in the first place — banking financial modeling.

Banking cash flow financial models

Modeling journey comprises three parts. First comes the plain-vanilla commercial banking model stripped to its essence. I start from the utmost simplistic version of it, a sort of a "spherical horse in vacuum," aimed to demonstrate the banking income generation and key interconnections among financial statements in the hypothetical world of no credit risk or regulatory requirements. Then I'll show the way accountants handle credit risk by adding loan provisions into the model. The final step will introduce capital and liquidity regulations, and voila — the baseline modeling engine will be ready to go.

Since the attached models are fairly well-commented, this section won't get into all the steps and details of model building — just the essential ones for you to get started.

Step 1: Plain vanilla commercial banking model

Modeling most industrial businesses is a P&L exercise. Revenue is typically a basic driver for the whole operating model. Starting from revenue growth assumptions, you gradually model other items in the model that use revenue to derive their value. Modeling balance sheet is typically welcomed, but it's not a must and some simpler models do well without it.

Different with banks. Balance sheet outranks P&L in the statements' pecking order. You first project key balance sheet items, then P&L, then CF if necessary, and finally link them together. Take a close look at Figure 9, where the main flows between the three banking statements are shown. Let's follow the steps on the chart to see how the basic model is built.

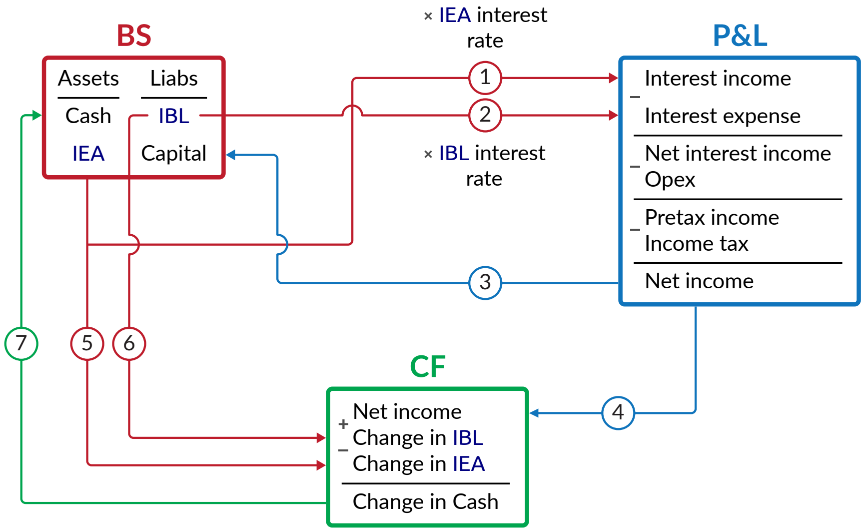

Fig. 9 Flowchart of a plain vanilla commercial banking model

(1) and (2): You start by projecting key balance sheet items — *interest-earning assets* (IEA) and *interest-bearing liabilities* (IBL). IEA in this case are essentially loans, while IBL are mostly deposits. Once those projections are in place, you assume returns on IEA and IBL — weighted-average interest rate on loans and weighted-average interest rate on deposits, respectively. Multiply interest rate by the asset / liability volumes, and you get interest income / expense, which are exported to P&L to forge the net interest income there.

(3) and (4): You do all P&L workings from the net interest income down to the net income. The latter then goes to BS by increasing (if you are lucky) bank's capital, and also to CF as a key operating cash item.

(5) and (6): Changes in IEA and IBL are forwarded to CF as two more operating cash items.

(7): Having finished with CF operations, you arrive at the net change in cash over the period. To complete the modeling mechanics, this figure moves to the cash account on BS.

Done deal! This is the logic of a commercial banking model as simplified as it could possibly be. Now it's time for you to see the actual workings in the attached file `Wb_4_Plain_vanilla_banking_model.xlsm`, before you move on to the next

Step 2: Adding credit risk accounting

OK, so the starting model is up and running. As long as net income is positive, the current setup generates cash like crazy. A nice way to make a fortune, I believe... But wait a minute, isn't it too good to be true? After all, loans are known to default sometimes! Which eventually generates losses. How does the model capture that?

You are right, it does not. As yet. And that's what we're gonna fix right away.

First let's talk the terminology. When a loan payment is due on a specific date and the borrower fails to pay on that date, a bank faces *delinquency* in payment. If the latter keeps up long enough, it eventually becomes a *default*. When a bank writes the defaulted loan off its books, then it's a bank's *gross charge-off* (or gross loss). When that happens, legal process starts which sometimes results in partial recovery either through the sale of a seized collateral or further cash collection of the loan. So finally *gross* charge-off becomes *net* charge-off (or net loss).

Consider Figure 10 which shows how the essential credit risk accounting is incorporated into the baseline model.

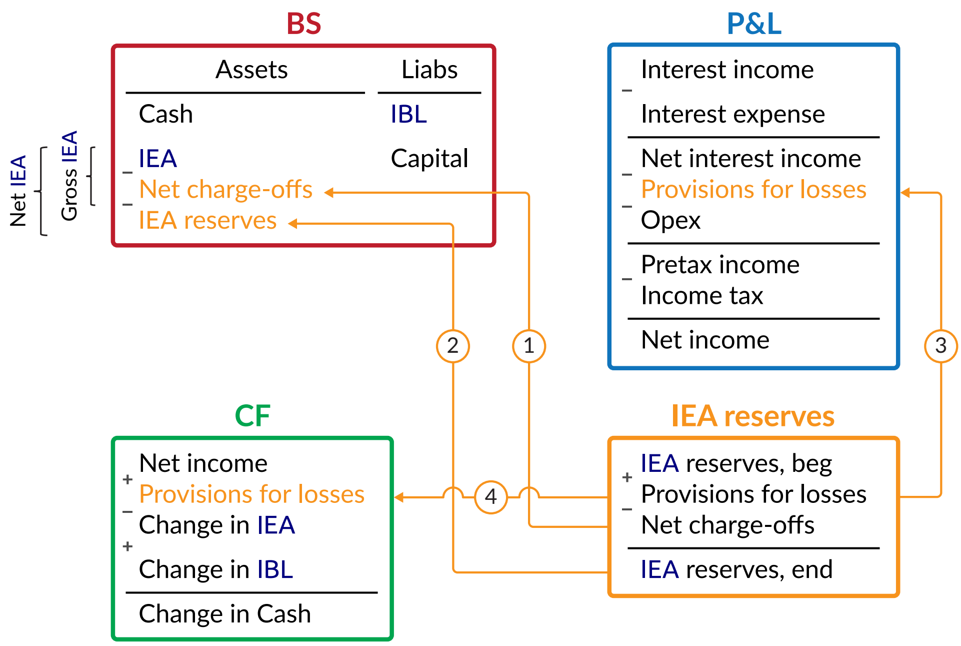

Fig. 10 Basic credit risk accounting

IEA reserves account: Banks expect defaults. From their experience and huge set of statistics, they know for sure there will be ones. And they *provide* for default losses before they even face them. That's what *provision for losses* is for — an actuarial expectation of a loss likely to be experienced during some future period. The accumulation of provisions tops up IEA reserves account.

Over time the actual, realized losses on IEA present themselves. As I said above, those are *net charge-offs*. As opposed to provisions, net charge-offs are not statisticians' fantasies — they are real-life losses. So they offset increases in IEA caused by provisions. Hence the IEA reserves corkscrew.

① and ②: Since we now embrace defaults, net charge-offs are incorporated into gross IEA by decreasing their balance. So gross IEA now equals IEA less net charge-offs. Furthermore, IEA reserves balance is used as a contra account to reduce the value of gross IEA, which results in net IEA balance sheet item.

③: Current period's provisions for losses go to P&L as a non-cash charge decreasing a bank's pretax income.

④: The same value appears on CF as an add-back item in arriving at operating cash flow.

The attached file `Wb_5_Credit_risk_accounting_added.xlsm` integrates the above logic into the baseline model developed in the first step's `Wb_4_Plain_vanilla_banking_model.xlsm`. You may want to take time to study it carefully.

Okay, so far we've reached the phase of the model where it performs pretty well. Looks like there's light at the end of the tunnel. But how about the notorious regulation? All those adequacies and liquidities? Glad you asked...

Step 3: Adding regulation: capital

As we saw in the Regulation section, Basel III regulations are far too granular for efficient implementation *as is* in most cash flow financial models. Yet without regulations ingrained, a banking model can't be considered fully valid. A Catch 22? I'm afraid so. And there's no easy way out, from what I can tell. You *have* to use some simplified, proxy model that would approximate Basel III models with a certain degree of accuracy. You face, by and large, just two compromise options:

Rely on third-party models It's likely that you are not the first one to come across this dilemma. As you'll see in the next Step 4: Adding regulation: liquidity, there are some proxy LCR and NSFR models within reach. So you can go ahead and incorporate one of those into your model, just like I'll do it on page 28. It's relatively easy, but at the expense of a partial loss of control over your model. Could be annoying, at times.

Build your own models If you did not sleep through most of your statistics classes at the university, you can try and build your own proxy models. The premise is simple: you need to estimate the weighting coefficients for a simplified asset / liability structure that you have in your financial model, rather than taking Basel III coefficients which are intended for rather granular structures. So, loosely speaking, if Basel III is designed for Table 1 on page 11, then your model should redesign it to apply to Table 2 on page 12. To do this, you will need data, you will need some similarity measure, and you will need time, and you will need enough motivation. But the inherent upsides are pleasant, too.

All the above is of course equally applicable to liquidity models.

With this intro, let's get to the problem at hand. I start from the low-hanging fruit first.

As I discussed in the Capital adequacy requirements section on pp. 15–19, the idea of capital regulation is rather simple — just make sure each of the several ratios which include one or another member of the capital family in the numerator, and risk-weighted or plain asset metric in the denominator, is above its prescribed floor. Look at the diagram at Figure 11 which visualizes this logic, with cet1, t1, tc, and ta being floor values for CET1, T1, Total Capital, and LR, respectively.

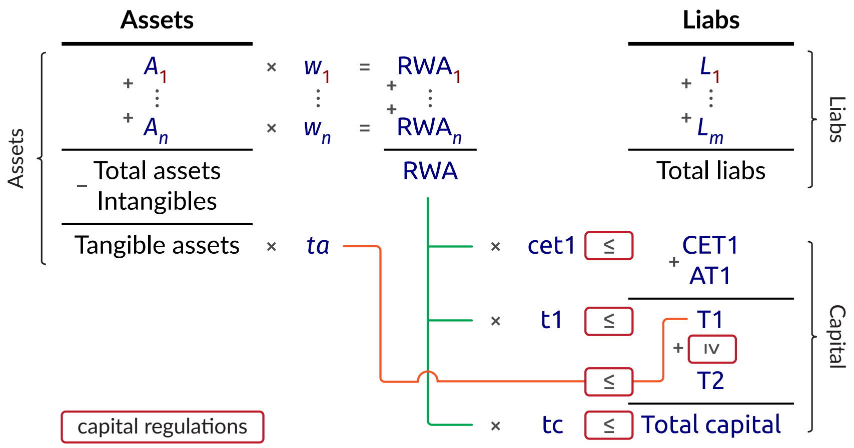

Fig. 11 Capital adequacy regulations

The only tricky part here is RWA calculation. Just like any other regulation, in its precise form it's far too complex for direct application in most of the cash flow models. So you'll have to make some type of a simplifying assumption. Specifically, you can follow one of the two approaches:

Causal Can be employed if you have historical data on values of RWA and other financials in previous years. Then you can think of some causal model that ties RWA to some other financial metrics like gross loans or total assets. And thus project RWA based on those metrics' forecasts. The model can be as primitive as simply calculating and smoothing historical ratios like Total RWA/Total assets, or more advanced regression models. The main advantage here is of course simplicity. Yet getting solid results requires that the projected RWA are aligned with the risk profile of the assets. Otherwise you get total BS, and don't you think I'm talking about balance sheet here.

Analytical You need to come up with some proxy of a Basel III risk-weighting model, as I discussed on the previous page. Or, you could use a third-party model. Sadly, for all I know, no RWA-related proxy models exist in the public domain. This is a real shame, because quick-and-dirty in-house RWA calculation is the first need you come across as a banking modeler. So you'll have to flex and stretch your modeling talent here in making your own RWA calculation engine. Using the help of your client, by all means. In return you'll get the utterly robust engine that can tolerate any changes in a bank's risk profile.

In the following model, for demonstration purposes, I adopted much simpler approach, giving my own expert estimate for each weighting coefficient w_i for each aggregated group of assets. These were previously reinforced by the client in one of my previous projects. Quite unsporting, I admit. In the real-life financial model, you'll have to back up your estimates by an analytical proxy model as we just discussed.

Time to run Excel. `Wb_6_Capital_regulation_added.xlsm` will guide you through the capital adequacy calculations. Once you get accustomed to that, look ahead to the final step of the modeling exercise —

Step 4: Adding regulation: liquidity

As you're well aware by now, there are two metrics to track here — LCR and NSFR. Unlike RWA metric that lacks a standard proxy calculation legitimate for not-so-detailed cash flow models, liquidity metrics can be simulated with the existing proxy models. There could be a continuum of those, of course, but for the purposes of this demonstration I use the one proposed by Hoerova et al. [4], pp. 17–18 and 40–41.

Let's investigate Figure 12 which sets forth key steps in arriving at the value of LCR proxy. It's a very simplifying methodology. For example, among other reductions, it totally disregards the existence of *OBSA*.

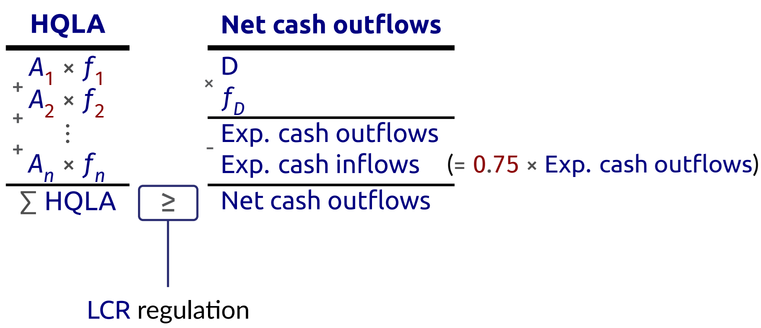

Fig. 12 LCR proxy calculation mechanics

The notations read as follows. A_i is the aggregate value of the i-th liquid asset category, like "cash" or "securities." These are asset aggregates that you deal with in your financial model. For each liquid asset category, f_i represents the average factor (as introduced on page 21) associated with that category. How are those determined?

Table 1 on p. 40 of the cited paper shows 5 groups of liquid assets (cash, deposits at central bank, government debt, corporate debt, and equity securities) each with the corresponding factor. If these liquid asset categories coincide with those in your model, just go ahead and apply the presented methodology to get LCR (with some comments to follow). But what if your asset categories are different from those? You need to somehow “marry” the asset categories in our model with these 5 categories. One way to do it is this: assume some breakdown on each of “your” liquid assets by those 5 categories. As before, use the data you have access to and your pro judgment. Take the “cash” item, for example. Its breakdown for your case by the 5 categories could be something like “50% ‘Cash’, 40% ‘Deposits at central bank’, and 10% ‘Other securities’.”

Next, multiply that breakdown by the corresponding factors set forth in Table 1, and by doing so come at the average factors, f_i. Finally, “sumproduct” A_i and f_i to get the total HQLA value. Look at the Excel excerpt in Figure 13 to follow the logic.

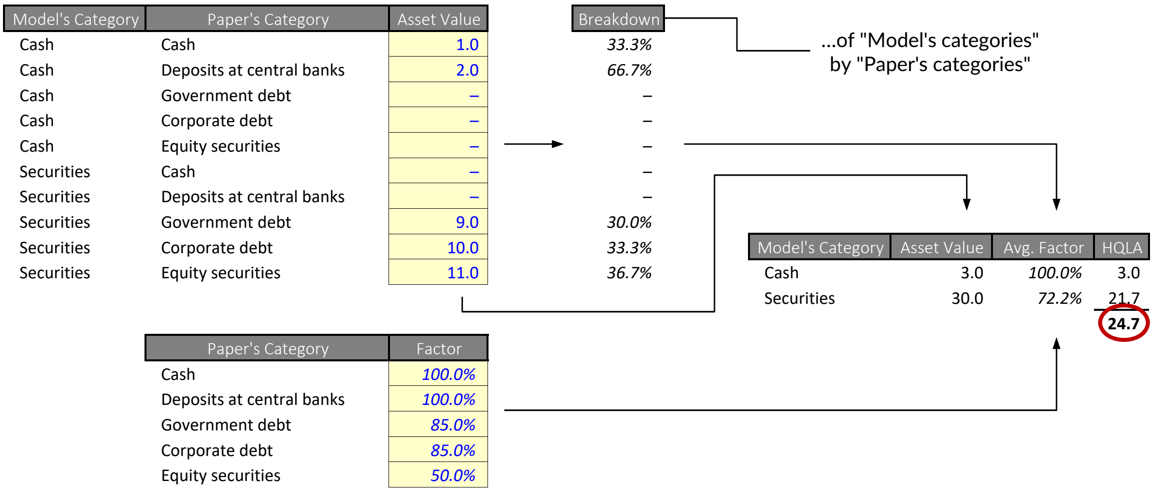

Fig. 13 Schematic of HQLA calculation

Note the “encumbrance coefficient” beside the “government debt” and the “corporate debt?” *Encumbrance* is the situation when an asset is subject to arrangements that restrict a bank’s ability to transfer or realize that asset. For instance, when an asset is used as collateral to raise secured funding, or in ABS transactions. The asset encumbrance (AE) ratio is the fraction of encumbered assets over total assets.[16] The higher the AE ratio, the lower the asset’s ability to serve as HQLA. So, “encumbrance coefficient” in Table 1 is the fraction of assets left “unencumbered,” that is, 1 – AE ratio. The best source of AE ratio for the bank you analyze is certainly your client.

On the liabilities side, a similar idea to weighting deposits D is employed.

Then, Expected cash inflows calculation simplifies the formula 21 to a mere

$$\text{Net cash outflows} = 0.25 \times \text{Expected cash outflows}.$$

And finally, $\text{LCR} = {}^{\text{HQLA}}/_{\text{Net cash outflows}}$.

That’s all about LCR. Likewise, NSFR calculation follows a similar procedure based on Table 2 on p. 41 of the cited paper. It’s left to you as a homework.

Don’t forget to visit the file `Wb_7_Liquidity_regulation_added.xlsm` and follow the steps to complete the liquidity regulation section of the model.

Now that might have been the end of the story. By now you've got a simple but solid and fully-functional model. You can start from it and develop it further for your applications and projects. Yet as an icing on the cake I will offer below a simple cash flow valuation module, just to give you an idea of what peculiarities you would encounter with valuing banks.

Bonus step: Adding valuation

Cash flow valuation module is a useful part of any model. Not least because it provides equity valuation figure at any time on demand, which is by all means a nice feature to have. Let's therefore make a simple one just to demonstrate the eccentricity of the valuation technique in banking case. Please note that what I show below is just a rough sketch of what precise valuation engine could look like, for the reasons I clear up below.

Unlike many non-financial valuations, banking valuation is never done with a FCF**F** metric. As opposed to non-financial companies, operations and financing is undistinguishable for banks, as we talked in the Introduction. Therefore it is always FCF**E**-like metrics that are adopted.

FCFE, by definition, is the top amount that a bank can afford to pay out as dividends. So it all boils down to the question of "how much dividends a bank can pay?"

But it's a question of banking regulation. Dividends deplete bank's capital, and thus directly deteriorate capital adequacy ratios. Hence it's CARs that primarily drive FCFE valuations.

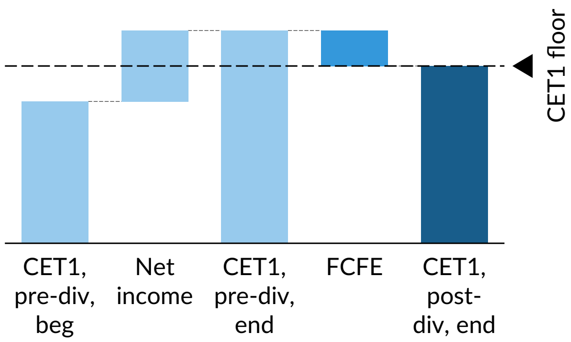

Fig. 14 The idea of FCFE calculation

The basic approach would be as depicted in Figure 14. I assume here that we perform our valuation based on the CET1 ratio. Consider a period of time, t. At the beginning, you have $\text{CET1}_t^{\text{beg}}$(pre-div) capital brought forward from the previous period. If nothing else happens, at the end of the period you would have $\text{CET1}_t^{\text{end}}(\text{pre-div}) = \text{CET1}_t^{\text{beg}}(\text{pre-div}) + \text{Net income}_t$. If $\text{CET1}_t^{\text{end}}$(pre-div) is above the CET1 floor determined by the CET1 ratio floor times RWA, a bank has a room for a dividend payment in period t. The maximum dividend allowed in period t would be

$$\text{FCFE}_t = \max\left\{0, \text{CET1}_t^{\text{end}}(\text{pre-div}) - \underbrace{\text{RWA}_t^{\text{end}} \times \text{minimum CET1 ratio}}_{\text{CET1 floor}}\right\}.$$

And finally, $\text{CET1}_t^{\text{end}}(\text{post-div}) = \text{CET1}_t^{\text{end}}(\text{pre-div}) - \text{FCFE}_t$, which amount is carried forward to the next period, $t+1$, as $\text{CET1}_{t+1}^{\text{beg}}(\text{pre-div})$.

This is as far as forecast period cash flows are concerned, say for $t = 1, \ldots, T$. What about the terminal value (TV)?

The naïve way would be just setting $\text{FCFE}_{\text{terminal}} = \text{FCFE}_T \cdot (1+g)$, where g is the assumed terminal growth rate. It's a dumb approach for any valuation, and it's no better in the banking case. Apart from general inaccuracy, how would you ensure capital regulations are not breached? No way to provide this, unless your approach establishes total compliance *by design* of it.

For illustration, I employ exit multiple approach, with P/CET1 multiple, a one similar to P/E in a general case. So TV estimate is going to be

$$\text{TV} = \left(\frac{\text{P}}{\text{CET1}}\right)_{\text{terminal}} \times \text{CET1}_{\text{terminal}}^{\text{end}}(\text{post-div}),$$

and the question now is how to determine the second product term. The idea is easy: just take a product of CET1 ratio floor and terminal RWA. Thus, it's all about how you estimate the latter, RWA. My advice is taking terminal RWA as a multiple of a key balance sheet driver. In our case of a classic commercial bank, gross loans would definitely serve that kind of a driver. So I set

$$\text{RWA}_{\text{terminal}} = \left(\frac{\text{RWA}}{\text{Gross loans}}\right)_{\text{terminal}} \times \text{Gross loans}_{\text{terminal}},$$

and the last question to answer is about getting terminal Gross loans. This last step is conventional — just set

$$\text{Gross loans}_{\text{terminal}} = \text{Gross loans}_T \cdot (1+g),$$

and the loop is closed. Mission accomplished!

Now go look into the file `Wb_8_FCFE_valuation_added.xlsm` to fully capture the idea of FCFE valuation.

One final remark on this. Clearly this is the most primitive valuation engine out there. There's a huge room for its improvement. The first natural question to raise is "how can you be sure all other regulations are met?" Well, you can't. With this engine, you can just hope for the best. One way to handle this would be incorporating the above FCFE calculation into the main model as a dividend calculation module, and then consider FCFE as one of the scenarios of dividend distribution. Since the main model has all markers of regulation compliance built in, this scenario will ensure FCFE valuation is in total conformity with all regulations — or the model will notify you visually otherwise.

* * *

The attached file `Wb_9_Final_model.xlsm` is an elaboration of `Wb_8`. While the latter is a good training engine, the former is a more full-fledged and production-grade one.

It's also tailored to be consistent with good modeling practices. Here are some of the differences made to `Wb_9` as compared to `Wb_8`:

- extended timeline;
- fleshed out financial statements;
- separate inputs and workings;
- added dashboard.

The final model was thoroughly tested and is reasonably robust. However, it was not tested for *every* possible combination of the input drivers. This task, should it be necessary, is left to you as a modeler.

Conclusion

Congrats! The model you've just built is a simple yet capable tool for capturing key interconnections in the commercial bank's cash flow analysis. You can use it as is, or you can build on it in any of the appropriate directions, like

- expanding timeline;
- making statements more granular;
- fine-tuning individual items;
- modeling relationships between items (like loans tied to deposits);
- enhancing credit analysis;
- reinforcing model's balancing mechanism;
- automating regulation modules;
- elaborating model into a comprehensive FP&A tool;
- many more, as you please.

Feel like delving deeper? Some of the sources looked at in the Introduction may help. But more crucial is your keen interest in the field and your inner confidence that any modeling issue you may face during the trip can be victoriously resolved.

* * *

Hope this was helpful. I would be grateful to hear your comments at my contact details.

Till next time on modeling tutorials. Ta ta,

Alex

About the author

Alexander Korotkov is a dedicated financial modeler with **anxtream**. With his relentless passion to modeling and versatile professional experience of over 15 years, Alexander offers comprehensive financial modeling services to the clients globally. In his previous career, Alexander had experience at a variety of business environments and cultures: from top industrial and financial companies to international investment banking boutiques, in diverse roles, from financial analyst to M&A advisor.

anxtream is an independent financial modeling advisory firm operating worldwide. Since our start in 2017, we have been assisting clients by providing versatile financial modeling services in line with world-class industry standards. We help building flexible, robust, transparent, logical, and efficient financial models that enable clients to arrive at smarter business decisions. Our services include building models for transactions, fundraising and operations, as well as model consulting. We appreciate models' quality and reliability above all.

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About the attached models

Here's the list of all Excel models embedded into this document, followed by some comments.

#	Name	Description
1.	`Wb_1_RWA.xlsm`	Illustration of RWA calculation
2.	`Wb_2_LCR.xlsm`	Illustration of LCR calculation
3.	`Wb_3_NSFR.xlsm`	Illustration of NSFR calculation
4.	`Wb_4_Plain_vanilla_banking_model.xlsm`	Basic commercial banking engine
5.	`Wb_5_Credit_risk_accounting_added.xlsm`	Above + credit risk accounting
6.	`Wb_6_Capital_regulation_added.xlsm`	Above + capital regulation
7.	`Wb_7_Liquidity_regulation_added.xlsm`	Above + liquidity regulation
8.	`Wb_8_FCFE_valuation_added.xlsm`	Above + basic FCFE valuation
9.	`Wb_9_Final_model.xlsm`	Full-fledged commercial banking model

All models are embedded into this article as attachments (yes, PDF allows that). If however you run into any trouble getting those files opened, you can always find the copies of them on **anxtream**'s website, anxtream.com.

No guarantee The models are provided without any guarantee whatsoever. I made good effort to make the models error-free, but I cannot guarantee absolutely the absence of errors there. Thus, if you use any of these models, you acknowledge that you do it at your own risk. That said, you are totally free to use the models any way you like, with or without any reference to me or **anxtream**.

Fictitious data All models use hypothetical input data, employed for illustrative purposes only. I can't guarantee any reliability of input data. Thus if you use any of these models for your own purposes, a thorough revision of the input data is highly recommended.

VBA The models intentionally rely on VBA for some macros and user-defined functions. It's possible to turn the VBA off without severely affecting the core functions of the models. However this may result in some minor problems with displaying the text labels in the models.

Color codes in the document

	Example
Internal link	About the author
External link	anxtream.com
Citation	[1]
Filename	Wb_9_Final_model.xlsm
Metric	ABCD
Math symbol	$\{+ - \times \div\}$
Math variable	Xyz
Math number	12345
Greek	$\alpha\beta\gamma$

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Notes

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7. Data from: US (Q2 2022), accessed 28 April 2023; UK (Q3 2022), accessed 28 April 2023; Denmark, Iceland, Norway, Sweden (Q3 2020), accessed 15 April 2021; rest of EU (Q2 2022), accessed 28 April 2023.
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15. NSF99 – Definitions and applications, accessed 28 April 2023.

16. For a precise definition, see Asset encumbrance in euro area banks, p. 8, accessed 28 April 2023.