IRM | institut du risk management BY Institut A

Mémoire présenté pour la validation de la Formation
« Certificat d'Expertise Actuarielle »
de l'Institut du Risk Management
et l'admission à l'Institut des actuaires
le

Par : William Arrata

Titre : Implementation of an insurance company's Asset Allocation with Exchange Traded Funds in application of the Look Through approach

Confidentialité : ☒ NON ☐ OUI (Durée : ☐ 1an ☐ 2 ans)
Les signataires s'engagent à respecter la confidentialité indiquée ci-dessus

Membres présents du jury de l'Institut des actuaires :

Membres présents du jury de l'Institut du Risk Management :

Entreprise : Banque de France

Nom : ARRATA William

Signature et Cachet :

BANQUE DE FRANCE
DIRECTION FINANCIERE ET DU CONTROLE DE GESTION

Directeur de mémoire en entreprise :

Nom : Nicolas MAGGIAR

Signature :

Invité :

Nom :

Signature :

Autorisation de publication et de mise en ligne sur un site de diffusion de documents actuariels
(après expiration de l'éventuel délai de confidentialité)

Signature du responsable entreprise

Signature(s) du candidat(s)

Secrétariat :

Bibliothèque :

SAS au capital de 96 550 euros - Déclaration d'activité enregistrée sous le n° 11 75 44451 75 auprès du Préfet de Région IDF
4, rue Chauveau-Lagarde - 75008 Paris - Tél : 01 44 51 72 79 - Fax : 01 44 51 72 73
Email : formation@institutdesactuaires.fr
Siret : 512 264 441 000 19 - Code NAF : 8559 A - TVA intracommunautaire : FR 25 512264441 - RCS Paris : 512 264 441

Sorbonne Université
Master in Actuarial Sciences
2019 2021

Implementation of an insurance company's asset allocation with Exchange Traded Funds in application of the look through approach

William Arrata

Memoir's tutor: Nicolas Maggiar (Banque de France)

Contents

Acknowledgements

I would like to thank first Philippe Mongars, Director of the Financial Directorate at Banque de France, and Claire de Crevoisier, then Head of the Financial Management Division at the Financial Directorate at Banque de France, for having accepted to finance the Master in Actuarial Science at Sorbonne Université before I joined their Directorate. I could not have embarked on this long term project without their trust.
I would also like to thank Valérie Dumas and Nicolas Maggiar, current Head and Deputy Head of the Financial Management Division at Banque de France, for their encouragements in my investigations.
At the ACPR, I would like to warmly thank Timothée Fluteau, Paul Reymondet-Commoy and Marc Domange for their encouragements, their precious explanations on many aspects of the Delegated Regulation, their assistance and their availability.
At the Directorate for Statistics at Banque de France, I would like to thank Vincent Guégan and Lucie Berthoux for helping me retrieve investment data on insurance companies.

In the asset management industry, I would like to thank Florian Cisana from UBS ETFs and Index Funds, Eve Bussière from SPDR ETF, Hubert Heuclin from BNPPAM ETFs and Index Solutions, and ETFs French representatives from Lyxor, XTrackers and Amundi for our conversations and for connecting me with their colleagues which answered all my questions.
My warmest acknowledgements go to Antoine Lesné from SPDR ETF Strategy & Research, to Victor Volard from BNPPAM ETFs and Index Solutions, to Gerald Daepp from UBS ETFs and Index Funds and to Laurent Lepoivre from BlackRock/iShares for their explanations, their willingness to share information and exchange views and their availability.

These last three years at Sorbonne Université would not have been that pleasant if I had not shared the course of my studies with Timothée Fluteau, Paul Reymondet-Commoy and Sophia Gazzola from ACPR.

Introduction

The introduction of Solvency II Directive in 2016 has dramatically changed the conduct of insurance companies' businesses in Europe. The Solvency Capital Requirement (SCR) counts among one of those major changes. Under Solvency I, the capital requirement of an insurance company was defined as a fixed percentage of provisions and there was a list of authorized and a list of restricted investments. Conversely, Solvency II relies on a risk-based approach which takes into account all business and financial risks an insurance company is exposed to. In particular, as all financial risks are now taken into account in the capital requirements, there is no specific investment restriction anymore as long as insurance companies constitute an amount of capital in adequation with the market risk incurred.

There is a prescribed list of business and financial risks that the insurance company has to address for the calculation of its SCR, and they are grouped into six general risk modules. In this memoir we focus on financial risks, which are covered by two of the six risk modules, namely Market Risk and Counterparty Default Risk. The Market SCR risk module is split into six submodules, such as Equity Risk or Interest Risk submodules. Among others, shares of Mutual Funds purchased by insurance companies expose to Market risk, but as no financial instrument is held outright by the insurer, the exposure is treated as "indirect". In such instances, the insurance company has to apply the "look through approach", whereby all the fund's exposures, i.e. investments or transactions it has entered, should be taken into account for the calculation of the SCR Market. In the same spirit, derivative contracts are concerned by the look through approach as they are also indirect market exposures.

This memoir aims at implementing the look through approach on a large dataset of European Exchange-Traded Funds (ETFs). We start from the observation that the implementation of the look through approach on such products is not consistent with Solvency II's requirements and we aim at applying it in a systematic and rigorous way to ETFs. We have chosen ETFs in this memoir, as they present a particular interest. First, they rely on various investment techniques, with varying degrees of complexity and varying associated risks. As such, ETFs held by insurance companies require quite sophisticated SCR calculations. Second, ETFs are, among mutual funds, one of the most transparent investment product. While the calculation of their SCRs can sometimes be data consuming and somewhat complex, it is readily implementable and calculations are reliable.

In the first part of this memoir, we introduce the specificities of ETFs in the universe of mutual funds, and we show the variety of investment techniques employed and the varying levels of complexity. In particular we show that many investment techniques employed by ETFs are likely to generate counterparty risk. Such a variety is expected to translate into different levels of SCR. We then present the database of European ETFs that we constitute by focusing on the ten largest European providers, which represent the vast majority of the market. We also detail the information collected on those ETFs.

In the second part, we provide with a thorough understanding of ETFs' risk management policies, especially regarding counterparty risk. Then we introduce the rules for the calculation of the SCR Market and the SCR Counterparty under Solvency II. Equipped with a solid understanding of ETF's exposures, we are able to apply SCR calculation rules to our database, and we present the resulting SCRs Counterparty and SCRs Market.

In the third part we exploit a dataset collected by the ACPR on all insurance companies established in France. We have at our disposal for all concerned entities their investments at the security level, at different dates. For one insurance company chosen randomly, we infer its Strategic Asset Allocation (SAA) from its holdings at the security level. Then we implement its SAA by using ETFs from our database. As we have many ETFs competing on each index of the allocation, there are many possible replicating portfolios of the SAA. To choose the optimal portfolio of ETFs for the insurance company, we develop a criteria of optimality for their selection. It is inspired from the usual models of index-linked portfolio management techniques and adapted to the insurance company's objective. But ETFS' SCRs are taken into account alongside their financial performances.

Then we conclude on the type of ETFs which is most suited for an insurance company.

1 The look through approach of Solvency II and Exchange-Traded Funds

1.1 Context of the study

1.1.1 The look through approach under Solvency II

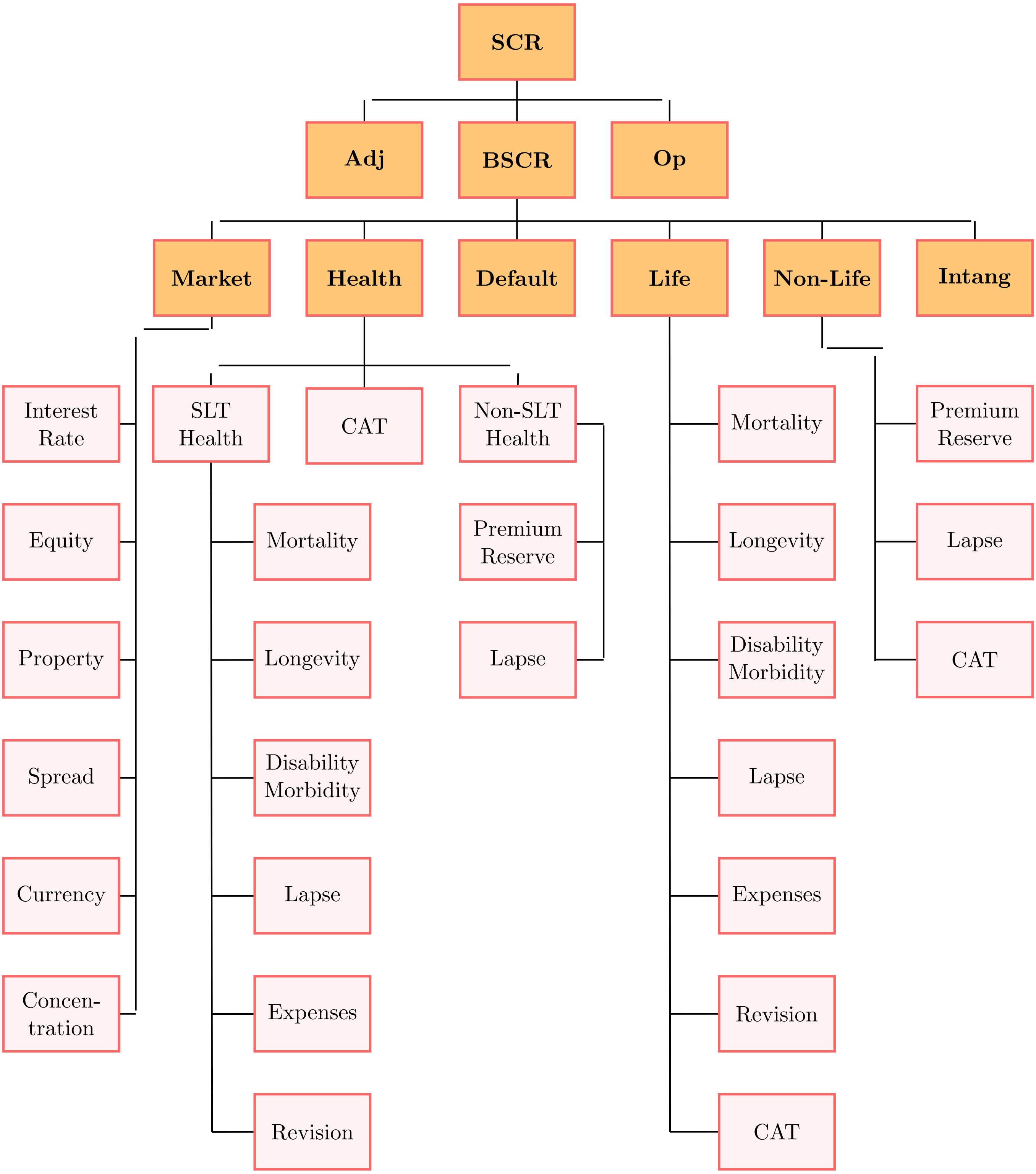
1.1.1.1 The SCR general principles

Since 1st January 2016, the prudential requirements of the European insurance sector have been governed by the Directive 2009/138/EC of the European Parliament and of the Council, known as "Solvency II principles". Solvency II principles are based on three pillars: Quantitative Requirements, Supervisory Review, and Qualitative Requirements. The first pillar encompasses a consistent market valuation of Assets and Liabilities, the calculation of a Solvency Capital Requirement (SCR) and the calculation of a Minimum Capital Requirement (MCR). Those principles, referred to as Level I text, are completed by the Commission Delegated Regulation (EU) 2015/35 of 10th October 2014 (level II text). The European Insurance and Occupational Pensions Authority (EIOPA), one of the European Union's main financial supervisory bodies, provided technical advice and support to the European Commission for the development of those principles. Then come Level III texts, in the form of Implementing Technical Standards (ITSs).

Under the previous regime (known as Solvency I), the Capital Requirement (then known as "Margin requirement") was defined as a fixed percentage of Provisions, thus taking into account the sole Liabilities side of insurers. Solvency II replaces the Margin requirement with the **Solvency Capital Requirement (SCR)**. The SCR is a risk-based measure which ensures that the level of Capital of an insurer is adequate to the level of risks it is exposed to. It is calibrated so that the probability of ruin of the insurance company at a 1-year horizon (i.e., the probability of a loss over the coming year exceeding its "basic own funds") be less than equal to 0.5%. The SCR is thus a Value at Risk measure of the distribution of the insurance company's losses arising from its different risk exposures.

There is a prescribed list of risk exposures that the SCR has to cover, which are classified into six general risk modules developed in Figure 1 below: **Market risk, Counterparty Default risk, Life, Non-life and Health underwriting risks, and Operational risk**. Many of them are developed into sub-modules. For instance, the Life risk module has sub-modules such as Mortality Risk and Longevity Risk. SCR calculation starts at the submodule level for all concerned elements of the insurance company's balance sheet. For each individual risk it is determined as the difference between the net asset value in the unstressed balance sheet and the net asset value in the stressed balance sheet. Such SCRs are then aggregated by submodules, and then by module, to ultimately get the SCR of the insurer.

Figure 1: Solvency Capital Ratios: risk modules and submodules



Stressing the balance sheet can be done using standard prescribed stress tests (or factors) for each risk exposure, an approach known as the Standard Formula (SF). It is developed in Chapter V of the delegated regulation under articles 83 to 221. However, the insurance company can also develop an internal model in lieu of the SF.

1.1.1.2 Market Risk module, Counterparty risk module, and the "look through" approach

As shown in Figure 1, Solvency II requires under the **Market and Counterparty Default risks modules** to mobilize capital for Market and Counterparty Default risks borne by an insurance company. Such risks are mainly induced by the investment of collected premia in financial markets and by hedging business and financial risks:

- **Market Risk** is the risk stemming from the variation in financial and real estate assets' prices and is declined into six submodules: Interest Rate, Equity, Property, Spread, Currency and Concentration.
- **Counterparty Default Risk** comes from the usage of Over the Counter (OTC) derivative contracts, contracts with Special Purpose Vehicles (SPVs) and some credit exposures not caught in the Market Risk module. Such contracts expose to the risk of default of the counterparty, i.e. the risk that the counterparty might not be able to fulfill its obligations. Counterparty Default risk will be referred to as Counterparty risk in this memoir.

The logic behind the submodules of the Market Risk module is an asset class logic to some extent. For instance, the Equity submodule applies to stocks, whereas the Interest Rate risk submodule applies to Fixed-Income products. Like for the Equities or Fixed Income products, investments in Collective Investment Undertakings (CIUs) or exposures to derivative contracts induce an exposure to Market Risk. A CIU is a group of pooled accounts held by an asset management company. The financial institution groups wealth from individuals and organizations to develop a single larger, diversified portfolio which invests into asset classes. A derivative product is a financial contract whose value is dependent on an asset or a variable, referred to as the underlying asset. The contract is set between two or more parties, which can trade on an exchange or over-the-counter (OTC).

To calculate the SCR Market of CIUs and derivatives, insurers have to implement the **"look through approach"**, as prescribed in Article 84 of the Delegated Regulation. The look through approach states that the insurer has to consider the risks of the underlying assets of exposures such as CIUs and derivatives, and not their envelope. PwC (2014) noted that "the look through approach is the main topic likely to influence the investments decisions of insurance companies. It imposes to detail the positions held by funds at the security level". For a CIU, underlying assets are the investments it has made and for a derivative, it is the asset on which payments of the contract are based. In any case, the insurer must apply any relevant Risk module to those assets, as if it were holding them.

The look through approach puts on an equal footing "direct" and "indirect" exposures to asset classes in terms of prudential treatment. As noted by PwC (2016), "This would give fixed income funds an equal footing to a direct bond holding, rather than being classified as an equity holding, thus requiring lower capital charges". In the same vein, entering a derivative contract on the stock of a company is rewarded with the same Market SCR than a purchase of that stock. If a fund holds another fund, then the look through approach must be repeated on the latter, until there is no indirect exposure anymore.

The look through approach also puts on an equal footing CIUs themselves. CIUs with the same investment objective in a given market segment are not always likely to invest clients' money the same way. Some may purchase the assets in the market segment, but other may use a derivative contract on those assets. Let us first review both strategies to show their economic equivalence.

1.1.2 "Physical" versus "synthetic" exposures

For instance, instead of purchasing a bond, the manager of a bond fund can use **a forward contract on the bond**, as it provides with an equivalent economic exposure. A forward contract is one example of a derivative contract. It is a contract to purchase an asset at some date in the future, the "maturity date", for a price determined when the contract is entered, the "forward price". Payment is made at the contract maturity and, to simplify, no cash outlay occurs when the contract is entered. Table 1 below compares purchase costs at time t and cash flows at maturity date T of buying the bond and buying the bond forward. The first strategy is referred to as a "physical" exposure and the second strategy as a "synthetic" exposure. It is assumed that the bond does not pay a coupon between t and T.

Table 1: Cash flows from the synthetic and the physical set up

Cash flows	t	T
Synthetic Bond exposure		
Cash loan (of the bond value at t)	$-B_t$	$(1+r)^{T-t}.B_t$
Buy Bond Forward	0	$-F_{t,T}$
Total	$-B_t$	0
Physical Bond exposure	$-B_t$	0

With:

B_t the bond price and the value of the cash loan at time t

$F_{t,T}$ the forward price at time t to purchase the bond at time T. This price is set to prevent an arbitrage opportunity between the two strategies, i.e., $F_{t,T} = (1+r)^{T-t}.B_t$

T the maturity date of the forward contract and the cash loan

r the lending rate of money

In the synthetic exposure, the price to purchase the bond at the maturity date of the forward is set in advance to $F_{t,T}$. At time T, the bond is effectively purchased at the forward price, with the money that was put on loan from time t to time T. Both strategies have the same cash flows and the same economic exposure. Compared to the physical exposure, the synthetic exposure is deferring the acquisition of the asset, but the commitment to purchase is firm and irreversible, which is why the strategy is economically equivalent to the immediate purchase.

One can make two variations in this strategy:

- It could be the return on the asset, not the asset itself, which could be delivered via the derivative. The return on this strategy would be the same as the one from a direct purchase. Indeed, from Table 1, returns on the direct and on the synthetic purchases are expected to be the same:
$$r^{Bond} = r^{Forward} + r. \tag{1}$$
As no asset is exchanged but a return instead, the latter is now calculated on a "notional", which is the product of the implicit quantity of the asset traded in the contract, times its market price.
- Instead of paying the return at one point in time, the strategy could embed many future payments at a regular frequency.

When the strategy includes the two previous variations, the arrangement is referred to as a **"swap"**. It is another example of a derivative contract. In general the return on an asset is exchanged against a fixed rate via the swap, at a regular frequency, often quarterly, semiannually or annually.

So far we have worked on an asset which does not pay an income, but most financial assets also pay a coupon or a dividend. When both asset return and income are periodically delivered against a fixed rate via the swap, the contract is referred to as a **"Total Return Swap" (TRS)**. TRSs are one of the main derivative instruments used by banks and other financial market participants.

1.1.3 Exchange-Traded Funds and synthetic exposures

Usage of TRSs is frequent in the universe of Exchange-Traded Funds (ETFs). ETFs are CIUs with two main peculiarities:

- **They are listed on an exchange**, like a share of stock. Trading on exchange can be done continuously throughout the opening hours of the day at the quoted price, and the minimum quantity to trade can be quite small. Trading on exchange usually involves shares which have already been issued by the fund: the exchange acts as a "secondary market". Conversely, traditional CIUs can only be purchased or sold at the end of the day, at an unknown price, via subscriptions and redemptions, i.e., by creating new shares or redeeming existing shares of the fund.

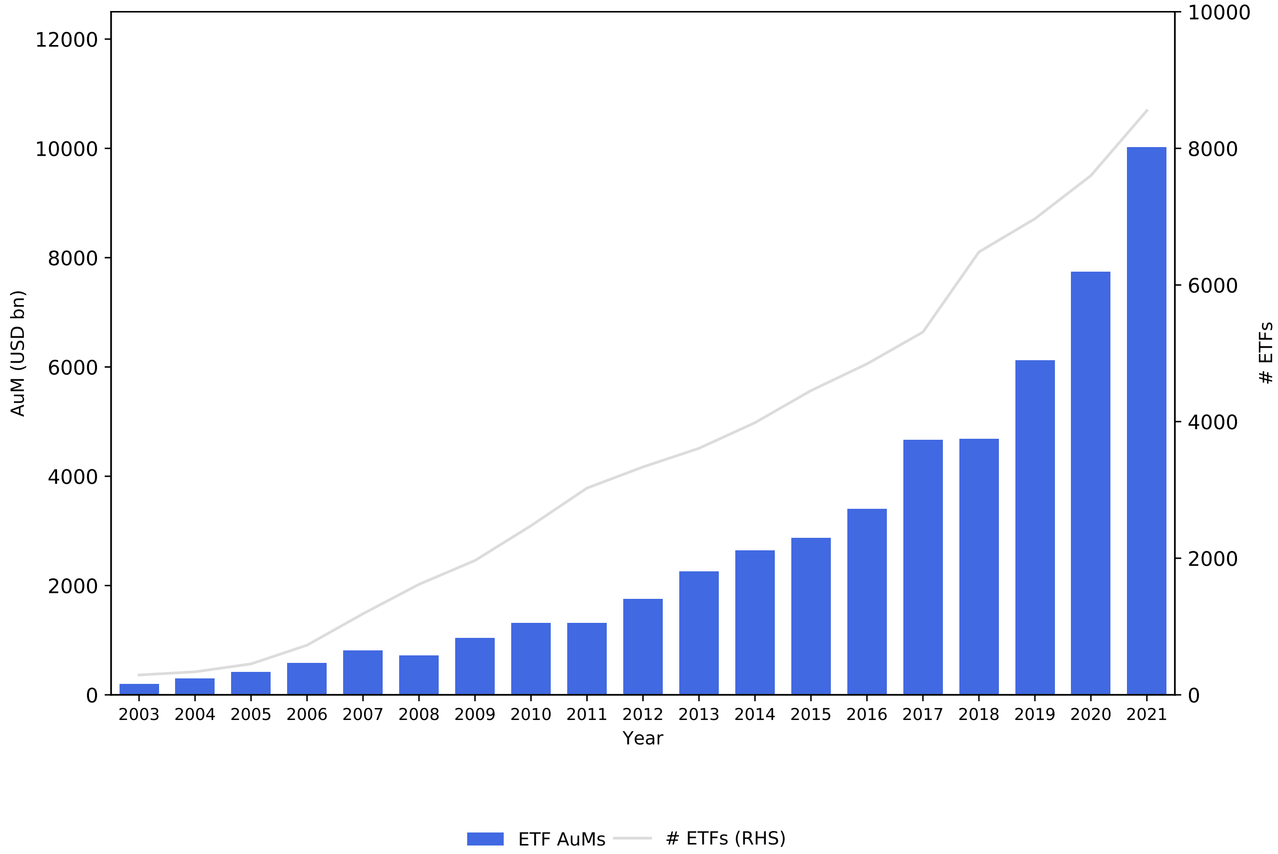
- **Their shares are created and redeemed in an original way**. An investor not willing to trade an ETF on exchange might still ask for a subscription or a redemption at the end of the day, like for traditional CIUs. But, as opposed to them, the investor never trades directly with the ETF, as all trades are intermediated by an **Authorized Participant** (AP), which is a financial intermediary designated by the ETF.

Two other important characteristics can also be found in other CIUs but are more prominent in ETFs:

- The investment objective of the immense majority of European ETFs consists in "tracking" (or "replicating") an index (an equity index, a bond index, an inflation index, and so on), i.e., they are **index tracking funds**. In effect, the return on an ETF is expected to be as close as possible to the one of the tracked index and this is the reason why they are sometimes referred to as "passive funds". Actively managed ETFs are growing in the United States though.
- As mentioned, ETFs can have recourse to TRSs to fulfill their investment objectives, as is the case for European ETFs. The synthetic "set up" can be found in a much higher proportion than for other CIUs.

The first ETF was launched in 1990 in Canada, and the market has experienced a tremendous growth in all geographic areas since then. According to the ETFs research consultancy ETFGI, ETFs Assets under Management (AuMs) worldwide reached 10.0 trn USD as of December 2021 (see Figure 2 below):

Figure 2: Evolution of global ETFs AuMs since 2003



Source: ETFGI website

The index-tracking capacity of an ETF is appraised through:

- the *Excess Return* (ER), i.e. the difference between the ETF return and the return on the tracked index. It can be measured at different frequencies, but the weekly frequency is most commonly used.
- the *Tracking Difference* (TD), i.e., the mean of Excess Returns
- the *Tracking Error* (TE), i.e., the standard deviation of the Excess Returns.

A two-year trailing period is commonly used to compute the latter two provided the ETF has a sufficient track record.

Tracking Error is the most widespread of those metrics. According to Bioy et al (2013), "Tracking Error is often cited as one of the most important considerations when selecting an ETF. It measures the quality of index replication, i.e. how well a fund manager replicates the performance of a specific index. Investors typically expect their ETFs to adhere tightly to an index."

The ETF return itself can be calculated in two ways:

- using the ETF **price on exchange**, usually the closing price
- using the ETF **Net Asset Value (NAV)**. ETFs are mutual funds and indeed are valued in the same way as other mutual funds following pricing methodologies, time stamps and sources that are reviewed and monitored by the board of these vehicles. The NAV is the value of their assets, net of the value of their liabilities, divided by the number of shares of the fund. It is published at a regular frequency, usually daily.

The physical and synthetic set ups that we have introduced are referred to as **"replication techniques"** in the ETF universe, i.e. techniques to replicate the return on the index of interest. The replication technique is one of the most prominent characteristics used to categorize ETFs.

As we mentioned, the usage of synthetic set ups is not peculiar to ETFs, but the development of ETFs fostered innovation in synthetic set ups and in physical set ups as well. We present below all variations within those set ups and review the economic rationale of each of them for an ETF.

1.1.3.1 Variations in the physical set up and economic rationales

There are two main forms for the physical set up: full replication and sampling. Both set ups can implement securities lending as well.

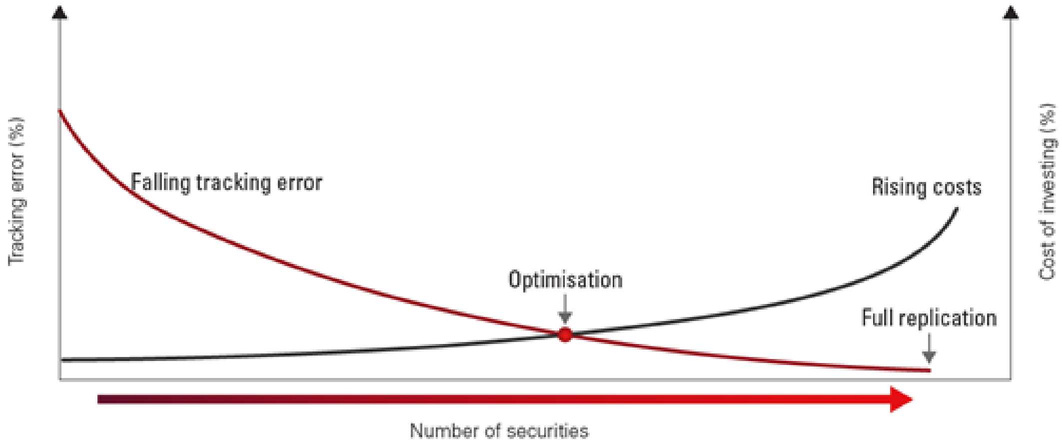
i. Full replication

Full replication consists in purchasing each index constituent in the same proportion as in the index. It is primarily applied for narrowly defined investment universes where liquidity permits such techniques without dragging too much on performance, or for exposures with a relatively low number of securities where idiosyncratic risk is high. While primarily found for ETFs tracking nominal or inflation-linked Treasury bonds indices, full replication is getting more common in the Equity ETFs world.

ii. Sampling and Optimization

Physical funds do not always implement full replication. Often, **the ETF purchases a sample of the index constituents**. Some indices have a very large number of constituents indeed, and it is almost never operationnally efficient to implement full replication, as handling many constituents imply high transaction costs, such as bid-offer spreads (as for Emerging Market or thinly traded securities) and local market taxes (such as stamp duty in the UK or Financial Transaction Taxes in France). Such costs can put a drag on ETFs performance and eventually on their TDs and TEs, as index values do not factor in such costs. The aim of sampling is to match the main risk characteristics of the index (for instance, for a Bond index, issuer, yield and term) so as to behave as closely as reasonably possible in line with that index. It is not always focused on the most liquid securities but attention is paid to transaction costs indeed. ETFs which use an **optimization model** also hold a sample of the index, but they build this subset by running an optimization program. For instance transaction costs and TE can be jointly minimized, as illustrated in Figure 3 below:

Figure 3: Finding the optimal trade-off between transaction costs and TE



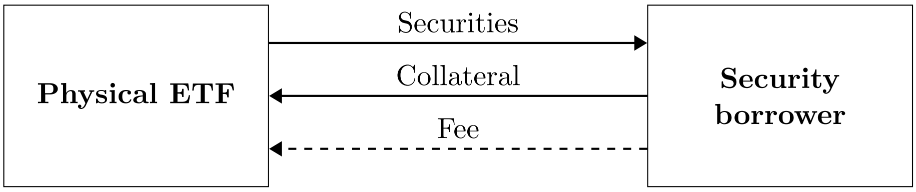
Source: Vanguard (2020), Fixed income myths, part 2: "Bond indexing is simple"

To simplify, we will refer to sampling to designate both techniques in this memoir. What matters is the fact that some ETFs only hold a sample of the index constituents, whatever the technique employed.

iii. Securities lending

Physical ETFs either in full replication or holding a subset of the index can also make use of securities lending. Securities lending consists in lending temporarily some of the securities held within the fund to a third party, the **security borrower**, in return for a fee. It has no maturity date assigned: the lender can "recall" the lent securities at any time. The security borrower has to post collateral assets to the lender to mitigate counterparty risk, i.e., the risk that the borrower might not be able to return the securities. Should the borrower fail to return them, the lender would take ownership of the collateral and sell it on the market. The proceeds would then be used to purchase securities not returned. Figure 4 below illustrates the securities lending set up:

Figure 4: Physical set up with securities lending



ETFs are the CIUs most likely to lend securities. Financial Times (2021) noted that "The value of ETFs' on-loan balances — the value of securities on loan at any point in time — rose 77 per cent, from an average of USD 37.5bn in 2017 to USD 66bn between January 1 and mid-May [2021], according to EquiLend, a securities lending platform. This dwarfed an overall increase of 21 per cent in the wider securities lending market". This more pronounced usage of securities lending by ETFs is due to their "passive" behavior with respect to the tracked index. Usually, indices "rebalance" (i.e., adjust their weights in their constituents or add constituents to stick to their objective) every quarter. As index trackers, ETFs adjust accordingly their positions at index rebalancing dates. Inbetween, ETFs portfolios exhibit no change in profiles, as no active management is involved beyong managing corporate actions, new issuance for fixed income ETFs, or specific credit events. Thus ETFs' holdings evolve in a very predictable manner. This is why ETFs can lend to a large extent their asset base without the need to recall too frequently.

Securities lendings can enhance ETFs' returns on at least three grounds:

- **By taking advantage of "scarcity"**: When ETFs hold securities which are scarce in the market and looked after, borrowers are likely to pay a higher fee to get them.
- **By reducing ETFs' income tax rate**. Lending temporarily transfers ownership of the securities to the borrower. In particular, the borrower will be subject to income tax if he has borrowed the security during the dividend payment date. When the loan terminates, the borrower returns the securities, but also the dividend to which the lender was entitled to, net of the tax paid. The ETF benefits from an after tax dividend at an advantageous tax rate compared to the one of its jurisdiction provided the borrower was subject to a lower tax rate.
- **By accepting risky assets as collateral**: Eventhough collateral posted by the security borrower is a risk mitigating element, it can embed more risk than securities lent out, a practice known as **"collateral downgrade"**. The risk characteristics of the collateral determine to some extent the lending rate indeed. The riskier the collateral (for instance, in terms of market volatility or credit rating), the higher the rate, as the lender is compensated for bearing that additional risk.

The economic rationale for securities lending and thus the motive for setting up a securities lending program varies from one provider to another. The main objective is to take advantage of scarcity as many providers do not pursue tax optimization or collateral downgrade anymore.

As the ETFs market is increasingly competitive, ETFs providers are often obliged to use securities lending to enhance ETFs returns.

To sum up, as index funds, ETFs are more prone than other CIUs to employ sampling or securities lending when they are in physical replication, because of the often large number of constituents of the tracked indices or thanks to the low and predictable turnover of their asset base.

1.1.3.2 Variations in the synthetic set up and economic rationales

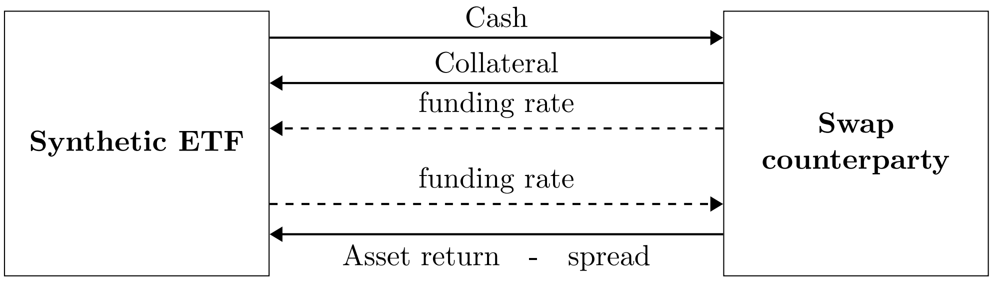
There are two main forms of synthetic set ups: the single leg swap set up and the two-leg swap sep up.

i. The single leg swap set up

The **single leg swap set up** closely resembles the introductory example with the forward contract, but the two transactions (loan and derivative) are bundled here. In this set up, the ETF purchases a single leg swap with the investor's money to the **"swap counterparty"**. With those funds, the swap counterparty then purchases the index constituents and commits to regularly delivering to the ETF the performance of the tracked index. It also posts collateral to reduce counterparty risk, in the same logic than for securities lending, as it would otherwise leave the ETF with an unsecured position.

As funding is provided by the ETF to the swap counterparty to purchase the index constituents, this set up is also referred to as **fully funded swap set up**. As mentioned, this set up can be analyzed as the packaging of a collateralized cash loan (also referred to as "reverse repurchase agreement", or repo) and a TRS. In Figure 5, we decompose the single leg swap flows as the sum of flows on a reverse repo and a TRS, but the implicit funding rates are not exchanged in practice:

Figure 5: The single leg swap set up



As the ETF counterparty is generally a bank, the funding rate implicit in the set up is a bank funding rate. In the euro area, the Euribor rate is the main bank funding rate. But a spread is also usually applied above or below that rate. As Euribor flows are not exchanged in practice, the ETF eventually receives the asset return, plus or minus a spread, referred to as the "swap spread".

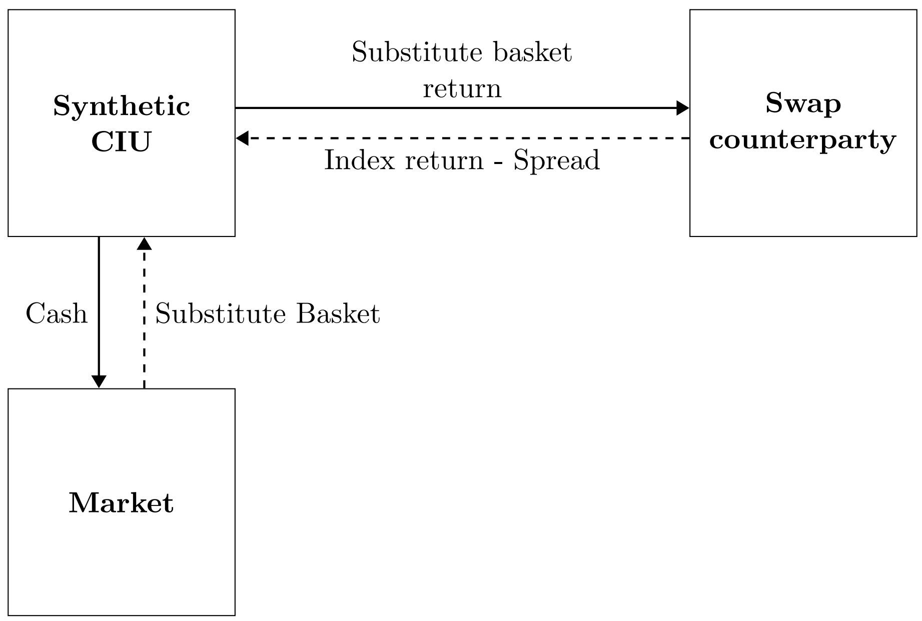
The single leg swap set up has been progressively abandonned by European ETFs providers in the 2010's and almost disappeared in 2017 as it was considered as too risky by investors and not demanded anymore.

ii. The 2-leg swap set up

In the **"two-leg swap set up"**, the ETF exchanges the performance of a basket of securities it has acquired against the performance of the tracked index. The basket of securities is referred to as the **"substitute basket"**, and is made of securities different from the constituents of the tracked index. This set up can be achieved with two structures.
In one structure, the ETF purchases a single leg swap on the tracked index (**"index swap"**), and simultaneously sells a single leg swap on the performance of the substitute basket (**"substitute basket swap"**). But the initial cash flows of the 2 swaps are netted so that there is no counterparty risk on the principal. When flows are netted, the 2 single leg swaps create a 2-leg swap. This set up is referred to as an **"outperformance swap"**.
In the other structure, the ETF purchases the substitute basket and exchanges its performance against the performance of the tracked index with the swap counterparty. This set up is referred to as a **"value swap"**.

In any case, the structure has two legs: the substitute basket performance is paid to the swap counterparty via the **swap paying leg**, and the tracked index performance is received by the ETF via the **swap receiving leg**. This set up is also referred to as **"unfunded swap set up"** (as eventually the swap counterparty is not provided with cash), and is represented in Figure 6 below:

Figure 6: The two-leg swap set up



In general, the seller of the substitute basket is the swap counterparty itself. As for the single leg swap set up, the ETF ends up receiving the asset return, plus or minus a spread, the swap spread.

Sometimes, both single leg and two-leg swap set ups can be used simultaneously, such that the ETF uses a **hybrid synthetic set up**. A portion of the cash raised is invested into a substitute basket which is swapped against the index performance (2-leg swap), and the rest is used to purchase a single leg swap on the return of the tracked index.

ETFs providers might be enticed, and even sometimes obliged, to use the synthetic set up to overcome the regulatory or operational constraints which prevent the physical set up from being used. There are also other instances where it is not compulsory to use the synthetic set up but where it remains more efficient to track the index. We first list situations where the synthetic set up is the only one in capacity to track the index, then situations where both set ups can be used but the synthetic set up is doing better than the physical set up:

a. Circumventing the limited access to the underlying assets

- Access to securities in an index might be restricted to foreign investors, as is sometimes the case for Emerging Market Equities. The ETF can choose a swap counterparty which is not subject to such restrictions.
- Sometimes, the index constituents are not physical (e.g., Commodities futures) and the index is already a "synthetic" index. So the ETF tracking that index is *de facto* synthetic.

b. Inconsistency of index structure with European or local ETF regulation

- **Constraint on Index concentration**: In Europe, ETFs are regulated by the Undertakings for Collective Investments in Transferable Securities (UCITS). An important aspect of UCITS regulation concerns diversification of the fund's assets, as it imposes that CIUs exposure to any given security cannot represent more than 10% of the fund's assets. Commodity indices sometimes have at most a dozen constituents and the weight on a given security can go beyond 10%. Swaps bring down to 0 ETFs holding ratios in index constituents and as a result, synthetic ETFs which track such indices are UCITS compliant.
- **Constraint on the ETFs assets, the case of the French Plan Epargne en Actions (PEA)**: In France, the PEA is a tax efficient share savings plan for individuals. An improved capital gain tax treatment is granted to an individual which purchases European Equities in such a plan. Shares of mutual funds are also accepted provided at least 75% of the fund's assets are invested in European equities. Thus, an ETF tracking the S&P 500 can be eligible to such a scheme only by using a 2-leg synthetic set up with a substitute basket made of at least 75% of European Equities.

c. Improvement of ETFs' holdings tax treatment (case of Equity indices).

- Total Return (TR) indices are indices which take into account coupons or dividends paid by their constituents. Dividends paid by stocks constitutive of such indices are fictively "reinvested" by increasing their weight in the index.
- Conversely, Price Return (PR) indices do not take into account income. It is forbidden for an ETF to replicate a PR index, as it amounts to depriving ETFs investors from the dividends to which they are entitled to as indirect holders of the securities.
- ETFs usually replicate Total Return indices which take into account income tax, i.e. Net Total Return indices. Such indices "reinvest" after-tax dividends, and the tax rate used in the index formula is a "standard" withholding tax rate.
- Yet, ETFs can improve their relative performance by paying a tax rate lower than this standard rate. This can be achieved by finding a swap counterparty subject to a lower withholding tax rate than the standard rate. As the swap counterparty replicates the index, it holds the index constituents and benefits from this favorable tax rate. Eventually, a higher after tax performance can be delivered to the ETF via the swap receiving leg.

d. Reducing transaction costs, market taxes and capital gain taxes (case of single-leg swaps)

- In the single leg swap set up, clients' money is invested or redeemed with a cash transfer between the ETF and the swap counterparty. For instance, a redemption is financially equivalent to the repayment of a collateralized loan position, as opposed to two-leg swaps which suppose trading the substitute basket, or the physical set up, where trading occurs on the index constituents. Thus no transaction costs and local market taxes on securities are incurred by the ETF in the single-leg swap set up.

- In addition, as redemptions do not trigger sales of securities, the ETF holder does not have to pay a capital gains tax.

Another argument also cited for the usage of the synthetic set up is the refinancing of investment banks balance sheets. Hurlin et al (2019) cite among the reasons for using the synthetic set up that "these swaps constitute a major source of funding for financial institutions and lead to synergies and cost saving with their investment banks which maintain large inventories of equities and bonds. Finally, they may also allow the banks that act as swap counterparties to reduce their regulatory capital by posting high risk-weight securities as collateral". Banks which act as swap counterparties usually sell to ETFs (2-leg swap) or post as collateral (single leg swap) securities that they already have on their balance sheets.

To sum up, there are many reasons indeed to motivate the usage of swaps by ETFs. But this usage is also made possible by the passive behavior of ETFs. ETFs' investment strategy can be "outsourced" to a swap counterparty provided the latter receives from the ETF every day the constituents' weights in the tracked index. Conversely, actively managed funds rely on investment strategies whose outsourcing would be more complex and would not necessarily improve the performance of the fund. For this reason ETFs are more likely than actively managed CIUs to use synthetic set ups.

1.1.3.3 Varying risk exposures for the same investment objective

All the replication set ups we have reviewed are economically equivalent, but differ in terms of risk exposures.

Synthetic set ups entail the same market risk exposure than physical set ups. Their net exposure is an index exposure indeed. But while physical set ups are exposed to market risk only, physical set ups with securities lending and synthetic set ups might also embed counterparty risk. The definition of counterparty risk we use here is the one from the Delegated Regulation. It is the situation whereby in case of failure of the counterparty to fulfill its obligations, the ETF incurs a loss.

- As opposed to direct exposures whose price variation is often immediately observable, **OTC derivative exposures must be "marked-to-market"**. Marking-to-market consists in updating the price of the OTC derivative with the most recent values of market variables (interest rate, volatility, etc) which determine its price. The updated value of the derivative translates into a receivable if it is positive, or a payable if it is negative. For a derivative on an exchange, no marking-to-market is necessary as the listing provides with a continuous price, and the resulting claim is settled on a daily basis in the form of a margin call. In an OTC contract, the marking-to-market might not be cleared immediately and be collateralized instead.

- **Marking to market also prevails for securities lending transactions**. Lent securities and collateral assets are subject to market price variations, and if the value of lent securities goes above the value of collateral, the ETF is left with a net exposure to counterparty risk and additional collateral has to be posted by the borrower.

Thus synthetic ETFs and physical ETFs lending securities are exposed to **"collateral risk"**, which is also referred to as **"shortfall risk"**. It materializes when the value of the collateral drops below the value of the receivable from the counterparty. This risk will be detailed in the next chapter, as well as the way it is managed by ETFs. In Solvency II regulation, this risk falls under Counterparty Risk.

The intermediate conclusion is that ETFs with the same investment objective may have different risk exposures and will not be subject to the same risk modules of Solvency II:

- **Physical funds** are exposed to market risk, and sampled funds might be exposed to a different level of market risk.
- **Physical funds lending securities** can be exposed to:
  - market risk
  - counterparty risk on the securities on loan
- **Single leg swaps funds** can be exposed to:
  - counterparty risk on the implicit collateralized cash loan
  - market risk on the swap receiving leg
  - counterparty risk on the swap mark-to-market
- **Two-leg swaps funds** can be exposed to:
  - market risk on the swap receiving leg
  - counterparty risk on the swap mark-to-market

Applying the look through approach on ETFs tracking the same index but using different replication techniques might then end up with different capital requirements, eventhough their investment objective is identical.

1.2 Subject, objectives and relevance of this memoir: implementation of an insurance company's asset allocation with ETFs using the look through approach

In this memoir, we calculate the SCR requirement on a population of ETFs by applying the look through approach. We calculate their SCR Market and also, if any, their SCR Counterparty stemming from securities lending and OTC Derivatives transactions. Then we implement the Asset Allocation of an insurance company with ETFs. We test all ETFs competing on each representative index of the allocation, and we keep the most efficient combination of ETFs.

To do so, we proceed in two steps.

First, we constitute a database with all ETFs from the 10 largest European providers, and we compute their Market and Counterparty Risk SCRs since 2016 at a regular frequency. Second, using the security holdings of an insurance company, we infer its Strategic Asset Allocations (SAA) that we translate into representative and "investable" asset class indices, i.e., tracked by ETFs. We then implement its SAA with all ETFs from our database tracking those indices.

As we mentioned earlier, there are often many ETFs in competition to track a given index. Thus there are many possibilities to implement a given SAA with ETFs, i.e. there are many combinations of relevant ETFs. Each combination (referred to in this memoir as **"replicating portfolio of ETFs"**) has its own financial performance and SCR charge, as ETFs competing on each index often employ different replication techniques. We are looking for the portfolio of ETFs which, among all replicating portfolios, delivers the best tracking performance, while minimizing capital charge: it is referred to as the **"optimal replicating portfolio of ETFs"**.

Bioy et al (2013) already stressed that while fundamental for choosing ETFs, tracking metrics can be completed by other factors to enrich the selection process: "It is important to mention that while all the tracking metrics we discussed [...], namely tracking error, tracking difference [...] are important factors to consider when evaluating an ETF, thery are not the only metrics [...]. Additional factors to take into consideration include [...] trading costs [...], ETF's market price relative to NAV [...], counterparty risk, [...] tax considerations." Thus our approach actually consists in bundling one of those factors, namely counterparty risk, as appraised by Solvency II, to the usual metrics used to select ETFs.

1.2.1 Relevance of the look through approach on ETFs

According to Article 84 of the Delegated Regulation, all CIUs might be concerned by the look through approach when it is applicable. However, ETFs are a compelling case for its implementation for the following reasons:

- **Data is available at a regular frequency on ETFs' securities lending and derivatives transactions** following the introduction in 2016 of the **Securities Financing Transactions Regulation (SFTR, see infra)** and thus SCR calculations can be carried out. Conversely, actively managed CIUs do not publish their holdings as frequently, and often do so with a lag creating potential reporting timing challenges.

- We showed that **ETFs are, as index funds, more prone than other CIUs to use securities lendings, swaps and sampling**, which are all likely to create deviations in SCR compared to their index. In particular, because of their frequent use of the swap set up, ETFs were listed as one of the investment products most likely to be affected by the introduction of the look through approach in the years before Solvency II went into force. The consultancy Price Waterhouse Coopers (2014) highlighted that "Synthetic ETFs also pose a few problems. In its current stance, Solvency II states that the swap should either be unbundled (i.e., that one leg must be booked as an asset and the other one as a liability) or considered as a mandate, which poses consolidation issues."

- ETFs are readily comparable because they all have the same mandate. Conversely, it is much more difficult to compare actively managed CIUs, as each CIU has its own strategy.

- **For many indices, there are plenty of ETFs in competition, often using different replication and lending techniques**. This is especially the case in Europe where the ETFs industry is very well developed and not as concentrated as in the US, as many countries have their own national "champions". As a result, competition on index tracking is more intense in Europe, and comparison between ETFs SCRs can be immediate.

But other elements motivate our focus on ETFs. They lie in the current lack of application of the look through approach by insurance companies on their ETFs' holdings:

- Article 84 of the Delegated Regulation makes some exemptions on the application of the look through approach. The insurer is allowed to forgo this approach and to consider the targeted asset allocation of the CIU for the purpose of SCR calculation when the fund does not deviate from it and when the look through approach is not enforceable. In the ETF world, the targeted asset allocation is the tracked index and ETFs indeed never deviate from their targeted asset allocation. However, using the latter only to compute the SCRs of ETFs amounts to ignoring securities lending and OTC Derivatives transactions when they are used by ETFs.

- Even when the look through approach is implemented, it can be flawed. **The current reporting template filled by asset managers for the application of the look through approach on ETFs is incomplete and does not accurately reflect capital requirements on securities lending and OTC derivatives transactions**. In the period preceding the introduction of Solvency II, ETFs providers, and in particular synthetic ETFs providers were concerned about potential negative impacts of the look through approach on ETFs capital charge and about the limited time and knowledge of insurance companies to apply the look through approach on their ETFs holdings. Club Ampère (Asset Management PErformance & REporting), a "structure" set up by asset management companies to exchange on financial reporting and their improvements, launched in 2012 a Working Group dedicated to Solvency II reporting. It was led by French asset management companies Amundi and Lyxor, and eventually came up with a standard reporting template based on an assessment of synthetic ETFs' effective exposures. Some ETFs providers fill it at a quarterly frequency for their insurance companies' clients to help them calculate the SCR of their ETFs' holdings. However, this template only considers counterparty risk arising from the usage of OTC Derivatives and forgoes the risk from securities lending. Moreover, the SCR counterparty calculation of OTC derivatives is not consistent with the Solvency II counterparty risk module (see infra). At last, this template is not acknowledged by supervisors such as French ACPR.

1.2.2 How relevant are ETFs for insurance companies?

Having shown how relevant it is to apply the look through approach to ETFs, one might wonder how relevant ETFs are for insurance companies. Actually, they increasingly outsource the management of their assets, for instance when they do not have enough knowledge of an asset class, when they lack access to it, or when it is too costly for them to invest directly. StatInfo, which is Banque de France's periodic publications on insurance companies' holdings, observed that, at the end of Q1 2015, insurance companies established in France had invested 22.6% of their assets into CIUs. At end of Q3 2021, this proportion had reached 31.1%. This trend to outsource the management of an increasing share of their assets had already been identified by Gallet et al (2017) which noticed that "investments in CIU shares [by French insurance companies] reach 56 bn EUR in 2017, a level much larger than the long term average (16 bn EUR on average since 2009). The proportion of CIU shares in the assets of French insurance companies rises from 25% to 27% in one year".

Amidst that trend, ETFs are increasingly used by insurance companies, in lieu of more traditional investment vehicles. They are sometimes seen as more advantageous than traditional CIUs, because of their lower management fee, their very wide choice of asset classes and strategies, their high degree of transparency and their high level of liquidity on exchange. Their objective of tracking an index might also be one reason for choosing them if the insurance company is more focussed on getting asset class exposure rather than on stock picking and active management.

This is why the subject we explore is a topical one, even though insurance companies are unlikely to entirely outsource their assets to ETFs providers.

1.2.3 Summary of objectives

To sum up, the objective of this memoir is threefold:

- To compute Market and Counterparty risk SCRs of European ETFs from the 10 largest European providers at any available date since 2016, by applying the look through approach.
- To recover the Strategic Asset Allocation of an insurance company using its holdings at the security level, and to wrap it up into representative indices.
- To translate this Strategic Asset Allocation into an optimal portfolio of ETFs in terms of financial performance net of SCR charge, using an optimization program.

1.3 Data

In this section we first present the population of ETFs we consider. Then we detail the data collected to implement the look through approach.

1.3.1 Construction of the European ETFs database

In our *memoir* we focus on European ETFs. As of December 2021, there were 1,928 European ETFs. According to ETFGI, as of that date, their Assets under Management (AuMs) had reached 1.5 trn USD, i.e., 15 % of global ETFs AuMs. According to Refinitiv, a major global provider of financial market data and infrastructure, there were 46 ETFs promoters in Europe in 2021, with the 10 largest ones gathering 93% of AuMs.

To build our database, we select ETFs from the 10 largest European providers. They are, from the largest to the smallest, **iShares** (ETF brand of Blackrock), **XTrackers** (ETF brand of DWS, the asset management subsidiary of Deutsche Bank), **UBS AM** (Asset management subsidiary of UBS), **Lyxor** (Asset management subsidiary of Société générale - Lyxor was acquired on 31^{st} December 2021 by Amundi), **Amundi** (asset management subsidiary of Crédit Agricole), **Vanguard**, **Invesco**, **SPDR** (ETF brand of asset management company State Street), **EasyETF** (ETF brand of BNPPAM, asset management subsidiary of BNP Paribas) and **HSBC AM** (asset management subsidiary of HSBC).

We exclude from the database ETFs with esoteric investment objectives such as inverse and leveraged ETFs. The objective of the latter is to offer on a daily basis a positive or negative multiple of the performance of the tracked index, thus they are not relevant in an asset allocation perspective. We also remove Exchange-Traded Commodities (ETCs) as they are not funds in segregated accounts, but bank notes. The vehicles we exclude account for only a small proportion of AuMs. We end up with 1,255 ETFs out of the total number of 1,928 European ETFs, as of December 2021. Our database is thus very representative of the European market. Table 2 sums up this information by provider:

Table 2: Ten largest European ETFs providers' summary information (excluding ETCs, leveraged and inverse ETFs) as of December 2021

Provider	**# of ETFs**	**# of shares**	**AuM (bn EUR)**
iShares	336	511	602
XTrackers	156	234	139
UBS	137	351	95
Lyxor	162	315	88
Amundi	130	222	80
Vanguard	28	75	77
Invesco	117	155	56
SPDR	104	120	54
BNPPAM	43	67	23
HSBC	42	42	17

Source: ETFs providers websites

It is important to notice that there are more shares than there are ETFs, **as many ETFs have multiple "share classes"**. There are at least three reasons why an ETF might have multiple share classes. One reason is when an ETF has a capitalization and a distribution share. The capitalization share does not pay dividends, whereas the distribution share is expected to pay a dividend at a regular frequency (during exceptional circumstances, providers can temporarily suspend or defer payments). An ETF can also issue different types of shares with each share quoted in a particular currency. At last, some ETFs have "hedged" shares. In such instances, the ETF invests in securities so as to track a given index, but part of the fund's assets are made out in a currency which differs from the index currency. This is achieved with the use of a derivative contract, for a notional equal to the value of the hedged shares. The hedged share is entitled to a proratized amount of securities within the ETF balance sheet, but also to the payoff of the derivative contract.

In all instances, multiple share classes have a common balance sheet, which is the ETF balance sheet. This explains why for any provider, the number of ETFs shares is larger than the number of ETFs. In total, the 1,255 ETFs shares have 2,092 share classes.

For the 2,092 share classes, we extract from Bloomberg their NAVs and the values of tracked indices, at a daily frequency since 2017. We also extract for dividend paying shares the dividend per share at each dividend payment date since 2017. This information is required to calculate the financial performance of ETFs (Tracking Differences and Tracking Errors). We extract this information for the 2,092 ETFs alive as of December 2021 only, as we do not use ETFs which were liquidated during the period in the optimization program.

Then, to implement the look through approach we need information on ETFs' positions in securities, securities lending and OTC Derivative transactions.

1.3.2 ETF's and indices' holdings in securities

ETFs' positions in securities are collected using Bloomberg or ETFs' annual reports. If ETFs are not physical, then we retrieve their substitute baskets. For each security we get from Bloomberg the following characteristics:

- their ISIN code.
- their weight in the index and the ETF at different points in time.
- the name of the security issuer.
- their country of registration.
- their currency.
- for Fixed-Income Securities, their category in the **Bloomberg classification BCLASS** at its most granular level ("Level 4"). BCLASS is a Bloomberg classification scheme which was initially designed to categorize securities within the Bloomberg Barclays Fixed Income indices. It was later expanded to cover any existing Fixed Income security. It assigns to each of them a sector. Level 4 classification is the most granular level of classification.
- for Fixed-Income securities, their option adjusted duration at different points in time.
- the credit ratings of fixed-income issues and the issuer ratings of Equities from the four rating agencies DBRS, Moody's, S&P and Fitch at different points in time.

1.3.3 ETFs' exposures to Securities Financing Transactions

We also retrieve ETFs' exposures to securities lending transactions and swaps. ETFs' degree of transparency on such transactions has always been important following the important scrutiny of regulators since the beginning of the 2010's, but the enforcement of the **Securities Financing Transaction Regulation (SFTR)** in January 2016 has enriched and systematized the disclosure of such information by providers. SFTR is part of post 2008 regulations aiming at fostering transparency on financial markets and improving assessment of systemic risk. SFTR requires from any entity in the EU as well as any UCITS taking part in a Security Financing Transaction (SFT) to report extensively on such trades. SFTR defines SFTs as "transactions where securities are used to borrow cash or securities. They include securities lending, repurchase agreements, buy and sell backs, margin lendings, as well as Total Return Swaps".

Most ETFs providers disclose in their semi-annual and annual reports information about their SFTs. From the data provided we retrieve the following elements:

- **For Securities Lendings transactions**

- The proportion of a fund's lendable AuM on loan and the proportion of a fund's AuM on loan at each reporting date. Some providers also disclose the average, the minimum and the maximum values of the proportion of AuMs on loan over the past year or years.
- The aggregated amount of a fund's AuM on loan and the corresponding amount of collateral received i) at the fund level and ii) by securities lending counterparty
- For each security received as collateral, the issuer name, its amount and some important characteristics (issuer, coupon, maturity, country), usually for the 10 largest securities in the collateral basket. Sometimes, the aggregated amount of collateral by asset class is provided instead.
- The collateral split by currency, country and maturity buckets at the ETF level

- **For OTC Derivatives**
  - The top 10 swap counterparties of the swap given separately
  - The notional of each swap in its currency and as a proportion of the fund's AuM for each swap counterparty
  - The maturity buckets of swaps, and sometimes the exact swap maturities
  - If relevant, the type of swaps used, e.g., index swaps, substitute basket swaps and swaps to modify the currency exposure for the hedged shares ("hedging" swaps)
  - The swap value by counterparty
  - The collateral posted or received by each swap counterparty, detailed by asset class, amount and currency

The number of European ETFs from the ten largest providers involved in SFTs during the period 2016-2021 are summed up by provider in Table 3 below:

Table 3: # of European ETFs of the ten largest providers involved in SFTs during the period 2016-2021, by provider

Provider	**physical ETFs lending securities**	**synthetic ETFs**
iShares	234	3
XTrackers	87	80
UBS	74	18
Lyxor	11	97
Amundi	39	62
Vanguard	12	0
Invesco	20	61
SPDR	22	0
BNPPAM	0	13
HSBC	27	0

Source: ETFs providers websites and annual reports

To our knowledge, this is the first time a database with information from ETFs' reportings under SFTR has been elaborated. It is the basis for the calculation of SCR Counterparty over the period 2016-2021. There a two reasons to develop a long time series of counterparty risk SCRs. First, we are interested in the evolution of SCR counterparty through time, and wonder whether it displays variability. Then, for the construction of an optimal portfolio, we estimate Tracking Differences and Tracking Errors using historical data. For consistency, SCR Counterparty must also be estimated using historical data. We use 5 years of price history to estimate TDs and TEs (see infra). Thus the same timeperiod must be used for SCR Counterparty estimation.

In our database, 526 ETFs have been lending securities and 334 ETFs have been using synthetic replication during the period. As of December 2021, a few of them had been discontinued, while some synthetic ETFs had been converted to physical replication as well during the period: 41 XTrackers ETFs, 9 Lyxor ETFs and 9 Amundi ETFs switched to physical replication from 2017 to 2021.

BNPPAM is the only provider not involved in securities lending during the period. Lyxor ceased all securities lending activity for its ETFs in 2020, Invesco resumed securities lending in 2019 while HSBC AM resumed securities lending in 2021, having interrupted such an activity for 7 years. Vanguard, SPDR and HSBC AM do not use synthetic replication, and iShares only recently initiated synthetic replication for a few ETFs.

Two counterparties do not provide sufficient information with respect to SFTR requirements on securities lending:

- Invesco discloses the proportion of NAV on loan by ETF in its annual reports, but is silent about counterparties or collateral. While collateral is provided on its website on a daily basis, there is no historical data available in financial reports.
- For one of the two Lyxor subfunds, securities lending information required by SFTR is absent after 2018, eventhough the associated ETFs were still active in securities lending.

As a result, we are not able to compute SCR Counterparty for some Invesco and Lyxor ETFs engaged in securities lending. If such ETFs were to be relevant candidates for the optimization exercice, we would nevertheless exclude them to guarantee a fair treatment between ETFs providers.

Regarding HSBC AM, securities lending reports are to be available in 2022 only, as securities lending resumed in 2021. When this memoir was wrapped up at the end of 2021, no report about that activity was available, so in our calculations we assume they do not lend over the 2017-2021 period, which is a reasonable assumption.

To sum up, it is not possible to compute SCR Counterparty on the 27 HSBC ETFs and on the 20 Invesco ETFs over the period of interest. All Vanguard ETFs lending securities (12 ETFs), all Lyxor ETFs lending securities (11 ETFs) and 54 XTrackers ETFs out of 87 lending securities lend only very tiny portions of their AuMs and/or only accept Investment Grade Bonds as collateral. As we ran short of time and as SCR Counterparty on those ETFs would be close to 0, we do not perform such calculations and assume their SCR Counterparty are equal to 0. To sum up, we perform calculation of SCR counterparty related to securities lending activity on ETFs of iShares, Amundi, UBS, Vanguard, SPDR and 33 XTrackers ETFs, i.e. on 402 ETFs representing 76% of ETFs involved in securities lending in our database. As our database covers 93% of European ETFs, the 402 physical ETFs lending securities used for the calculation of SCR Counterparty (out of a total of 526 physical ETFs lending securities) still represent the vast majority of European ETFs' securities lending transactions.

Computation of SCR Counterparty for synthetic ETFs and computation of SCR Market for Fixed Income ETFs is data and time consuming as it requires indeed an important level of granularity (see Chapter 2). This is why we compute Fixed-Income ETFs' Market SCRs as well as synthetic ETFs' Counterparty SCRs only on an ad hoc basis, i.e., for ETFs selected for the portfolio optimization program.

SCR Counterparty calculations also require information about counterparties' credit ratings (see again Chapter 2), all of them being investment banks. We thus extract from Bloomberg for all those counterparties the time series of their credit ratings given by the four rating agencies S&P, Moody's, Fitch and DBRS since 2016.

1.3.4 Insurance companies' securities holdings

We collect from the Directorate of Statistics at Banque de France data from ACPR (Autorité de Contrôle Prudentiel et de Résolution, the French prudential and resolution authority) on insurance companies' holdings. We are given access to **the holdings of insurance companies established in France** at a regular frequency since 2011. They are available at the most granular level, e.g., at the security level). The covered entities are all French insurance companies, as well as all French subsidiaries of foreign insurance companies. Company names have been pseudonymized by the Statistical Department of Banque de France.

This data is available at a yearly frequency before 2016, and at a quarterly frequency since 2016 onwards. We focus on the following fields, at the security level: the purpose of the investment (unit-linked or general fund), the country of incorporation of the security's issuer, the security's asset class, its currency, its market value, its exchange rate, its maturity date and its nominal for Fixed Income securities, and eventually the quantity of the security held by the insurance company.

The holdings of one insurance company drawn randomly will be used in this memoir, and holdings will be presented in an aggregated way (see infra). Raw data is confidential, but it has been anonymized in this memoir and in this format it is not confidential anymore.

2 ETFs' risk management policies on Securities Financing Transactions and calculation of ETFs' SCRs

In this memoir, we compute SCRs using the Standard Formula. An internal model could have been employed as well, but it would have been very time consuming and expensive to build, and would have brought little value added given our purpose. Indeed, we are not interested in the value of ETFs' SCRs *per se*, rather in the difference between an ETF's SCR and the SCR of its index, and also in the dispersion between SCRs of ETFs tracking the same index with different replication techniques. What matters is not how shocks are calibrated, rather that applied shocks be consistent between ETFs and indices. Shocks are directly applied to ETFs' asset values on a standalone basis, i.e. without consideration of the insurance company's balance sheet. Before we perform those calculations, we briefly provide with ETFs' risk management policies regarding counterparty risk stemming from securities lending and OTC derivatives. A good understanding of those policies is compulsory indeed to apply in a relevant way the counterparty risk module of Solvency II.

2.1 Risk management policies of ETFs on SFTs

Risks induced by the usage of SFTs by ETFs are highly regulated in Europe by a few major reference texts, some of which having already been mentioned: the UCITS Directive, ESMA's Guidelines, EMIR (specific to OTC derivatives) and SFTR.

We start with general risk management rules, then we focus on rules specific to securities lending and swaps.

2.1.1 General Risk Management Rules for SFTs

2.1.1.1 UCITS Directive and ESMA Guidelines' general principles on counterparty risk

Both UCITS Directive and ESMA Guidelines address counterparty risk.

UCITS directive defines Counterparty risk as an SFT exposure which is not collateralized. The counterparty risk exposure arising from securities lending and OTC Derivatives transactions is limited to 5% of the assets of an UCITS, or to 10% if the counterparty is a credit institution.

The European Securities and Markets Authority (ESMA) published in 2012 guidelines on ETFs and other UCITS issues reflecting the EU market supervisors' response to risks stemming from SFTs. These guidelines apply to UCITS management companies. They address many aspects of collateral received in the course of securities lending and OTC Derivatives activity, such as quality, liquidity, lack of strong correlation and concentration. All ETFs providers abide by those rules but there are sometimes differences of implementation as the guidelines are flexible:

- The criteria of high quality has not been characterized in the ESMA guidelines, which leaves room for interpretation.
- The criteria of liquidity is flexible and gives some leeway to ETFs providers. Indeed, it is stated that "collateral received should be valued on at least a daily basis and assets that exhibit high price volatility should not be accepted as collateral unless suitably conservative haircuts are in place". Thus more volatile collateral assets can be accepted provided a consistent haircut is applied to them.

2.1.1.2 Haircuts on collateral

As we already mentioned, securities lending and OTC Derivatives transactions are subject to marking-to-market, which is carried out on a daily basis by ETFs. The net value of the position obtained can be cleared with a margin call in the form of cash or securities' effective transfer, or by posting collateral in the form of cash or securities, such that counterparty risk is removed. But there is the risk that the security borrower or the swap counterparty defaults before the next marking-to-market. This could lead to a loss for the ETF if the marking-to-market of the position (value of securities lent net of collateral value or swap value) has translated into a receivable.

In such a case, the ETF will sell collateral assets but proceeds will not be sufficient to purchase what the counterparty owes him. **A haircut** is designed as an additional safeguard so as to decrease the probability that the ETF counterparty owes money to the ETF between two marking-to-markets. It is a percentage which is removed from the market value of the pledged securities.

For instance, for a securities loan, a haircut of 10% means that the collateral posted is worth $\frac{1}{1-0.1}$, i.e., 111% of the market value of the security on loan. Haircut levels are usually determined using risk indicators that take into account asset classes' volatility. The riskier the collateral, the higher the haircut, as the risk of an adverse movement increases between two markings-to-market. Haircuts grids by provider as of December 2021 are presented in Table 4 for the main asset classes (haircuts are likely to change through time depending on market conditions):

Table 4: Haircut by collateral type by provider

Provider	Equities	Sovereign debt	Supranational debt	Corporate debt	Cash	UCITs inc. ETFs
iShares	105-112%	102.5-106%	102.5-106%	102.5-106%	102.5-108%	Y[a]
BNPPAM	-	-	-	-	Y	-
SPDR	105-110%	102-105%	-	-	-	-
Lyxor	100-135%	100-110%	100-110%	100-115%	100-102%	100-135%
HSBC	105%-110%	102%	102%	102%	105%	105%-110%
Amundi	110.5%	105%	105%	105%	103%	Y
UBS (LU & IE)	105%	102% (0-1y) 103% (1-5y) 106% (5y+)		110% (0-2y) 115% (2-5y)	Y	-
UBS (Swiss based)	108%	usually 102%		104%	Y	
XTrackers	105%	105%	105%	105%	Y	-
Vanguard	Y	Y	Y	-	Y	-
Invesco	102-110%	102-110%	-	102-110%	Y	-

[a]selected Equity, Government Bond, Credit and Commodity ETFs in physical replication

Source: ETFs providers websites, annual reports and prospectusses

Haircut calibration is done at the provider level, thus haircut levels can vary between them.

The asset class categories in Table 4 are quite general compared to the diversity of the collateral data collected in annual reports indeed. We observe in the data that some providers accept less liquid or riskier collateral assets than other providers, which is consistent with ESMA's guidelines:

- Sovereign bonds such as Government Inflation Linked Bonds or Stripped Government Bonds (Bonds Coupons or Bonds Principal Repayments separated by banks and traded on a standalone basis) are often accepted. Such securities are mostly illiquid.
- Equities such as Small Capitalization Stocks, and even recently listed stocks are also accepted. It can also often be found in collateral assets ADRs (American Depositary Receipts, i.e., certificates issued by a US bank that represent shares in foreign stocks), such as ADRs on Chinese Equities.

Most ETFs providers accepting cash collateral are allowed to reinvest it. For instance, Vanguard uses a in-house money market fund, UBS uses a money market fund but also G7 Government Bonds, and Amundi reinvests cash on deposits. In this memoir, we ignore this aspect due tue a lack of information and time.

2.1.1.3 The collateral set up

Some collateral arrangements are based on pledge, i.e. the the collateral assets are pledged to secure the exposure. In such a set up, ownership rights do not transfer to the ETF. This set up is used by Invesco and XTrackers for instance. Conversely, an outright transfer of collateral gives the transferee the right of use of the collateral asset while ensuring that the transferor retains the economic benefit of the asset. This is the set up employed by Amundi and UBS, for instance.

We do not delve further into this aspect as Solvency II does not make a distinction in terms of prudential treatment between both set ups.

2.1.2 Risk Management policies specific to securities lending exposures

2.1.2.1 Accounting treatment of securities lending

The majority of providers keep securities lent on balance sheet and do not book securities received as collateral. However, Amundi ETFs book securities received as collateral on balance sheet while securities lent are not on their balance sheet anymore over the duration of the loan. Lyxor ETFs used to book securities received as collateral on their balance sheet. While it is not a risk management tool *per se*, the capacity of an ETF to realize collateral in case of a counterparty default might be linked to its accounting treatment.

2.1.2.2 Securities lending limits

ESMA has not edicted a rule on the maximum lendable share of a fund, such that theoretically securities lending may concern up to 100% of an ETF's assets in Europe. Each provider determines its own limits, which are summed up in Table 5 below:

Table 5: Securities lending limits by provider

Provider	**maximum lendable proportion of fund's assets**	**maximum lendable proportion by ISIN**
iShares	usually 100%	100%
SPDR	40%	95%
Lyxor	25% (3 ETFs at 20% and 1 at 100 %)	NA
HSBC	NA	NA
Amundi	45% (25% for PEA eligible ETFs)	100%
UBS	usually 50%	NA
XTrackers	49% (25% for PEA eligible ETFs)	100%
Vanguard	33%	NA
Invesco	50% (UST), 30% (other FI), 15% (Equity)	90%

Source: ETFs providers websites and annual reports

For Amundi ETFs eligible to the PEA, the securities lending limits are closely linked to the accounting treatment of securities lending operations. ETFs eligible to the French PEA are indeed bound to invest at least 75% of the fund's assets into European Equities. In Amundi's case, as securities on loan are not on the ETF's balance sheet anymore, assets on loan are capped at 25% of the NAV. Other providers also propose ETFs eligible to the PEA (BNPPAM, HSBC, Lyxor and XTrackers) and for some, the lending limit is also set at 25% of the NAV. But for XTrackers ETFs securities lent remain on the balance sheet and for Lyxor ETFs lent securities used to be removed from the asset base for the purpose of calculating the proportion invested in European Equities. To sum up, for Lyxor and XTrackers ETFs, lending limits stand at 25% of the NAV for PEA eligible ETFs but this is not related to the accounting treatment of securities lending operations.

Lending limits are also sometimes linked to the motive of the securities lending program. Some ETFs might lend during the dividend period to a counterparty subject to a lower income tax rate. For instance, ETFs tracking Japanese Equities are sometimes authorized to lend as much as 100% of their assets at once, as Japanese Equities all pay a dividend at the same time of the year.

2.1.2.3 Indemnification against collateral shortfall in case of security borrower's default

In case a security borrower fails to return the securities, the ETF gains ownership of the collateral, sells it on the market, and uses the proceeds to purchase the securities not returned. But a counterparty default is highly correlated with a distressed market environment. Grill et al (2018) observe that "First, similar to standard investment funds, large redemptions [of ETFs] as a response to increased counterparty risk would lead to forced selling of collateral securities by the ETF. This is likely to take place in the context of a market downturn as counterparty risk would become relevant in generally stressed market conditions, and may put further downward pressure on already falling asset prices." In case of a counterparty's default, there is the risk that collateral proceeds might not be sufficient to purchase the securities not returned, in spite of the haircut.

Most ETFs providers in Europe offer indemnification to ETFs shareholders in case of a shortfall between the value of securities loaned and the realized value of collateral: the indemnifier bridges the gap with its capital to make the ETF whole. But sometimes, the ETF is not exposed to the default risk of entities to which it has lent securities, rather to a single intermediate entity (usually its parent bank which has stepped in between ETFs and security borrowers). In this scheme, referred to as "principal based", indemnification is not possible, as a parent bank cannot provide to ETFs of its asset management subsidiary an insurance against its own default. UBS ETFs domicilied in Switzerland follow a principal based scheme. Indemnification entities by provider are summarized in Table 6 below:

Table 6: Indemnification entity against security borrower's default by provider

Provider	**Indemnification entity**
iShares	Blackrock
SPDR	State Street Bank and Trust Cy
Lyxor	Société générale
HSBC	HSBC Securities Service
Amundi	**no indemnification contract**
UBS[a]	State Street
XTrackers	Deutsche Bank
Vanguard	Brown Brothers Harriman
Invesco	BNY Mellon

[a]Excluding Swiss registered ETFs
Source: ETFs providers websites and annual reports

Amundi and Swiss-registered UBS ETFs have no indemnification scheme. Collateral proceeds might be insufficient to purchase securities not returned in case of a security borrower's default.

The strength of the indemnification contract varies from one entity to the other. Some indemnification contracts fully replace securities lent in case of collateral shortfall. Other contracts are not unconditional, such as the indemnification provided on XTrackers ETFs, which states that "Such indemnity does not fully cover the borrower's default because the Securities Lending Agent's contractual obligation to indemnify the Company for shortfalls is limited to the event of an act of insolvency in respect of a borrower. In the event of a borrower's default that is not covered by such indemnity and a simultaneous shortfall of collateral value, the Fund will suffer a loss." Other contracts provide indemnification against collateral shortfall for some collateral assets only. For instance, indemnification provided to HSBC AM ETFs does not cover collateral shortfalls of cash collateral eventhough cash collateral can be posted in many currencies and is thus exposed to currency risk.

From Table 6 we observe that indemnifiers are of different natures. Some ETFs providers rely on a bank while others use an asset management company.

ETFs providers do not disclose much information on the risk management policies of their security borrower's indemnifier and it is unclear whether reserving is carried out for such an activity. Schwartz (2014) documents that "Up until now, banks offering this kind of guarantee have not been required to reserve capital for the associated contingency."

Consistent with our findings, the Financial Stability Oversight Council (2014) observes that "Some asset managers are now providing indemnification to securities lenders as part of their securities lending business. There are likely benefits for asset managers from combining indemnification provision with securities lending, but there also is the potential for enhanced risks. Unlike banks, asset managers are not required to set aside capital when they provide indemnification. [...]. Consequently, the indemnification that asset managers provide may be a source of stress on their own balance sheets, while at the same time resulting in lower protection for the lenders relative to indemnities provided by banks."

This view is contested by Blackrock. Schwartz (2014) cites Blackrock's response to FSOC's report: "Many, like Blackrock, say that the contingency is so small as to be immaterial, both on an "expected value" basis as well as an assessment of "stress risk," and thus there is no need to reserve for it: "To date, we believe that the regulatory capital treatment of indemnification for U.S. agent banks has not been a significant contributor to risk weighted exposures and capital, as the overcollateralization of securities loans, often with Treasury securities or cash, translates to a low (or in some cases zero) risk-weighted charge."" To us, this view is not consistent with the usage of equity as collateral by security borrowers.

It also seems that cost is an important element to explain the absence of reserving. Schwartz (2014) underlines that "In addition to being unnecessary from a risk perspective, forcing lending agents to reserve for indemnity exposure or imposing liquidity requirements may also make indemnification uneconomically expensive or eliminate it from the securities lending business entirely."

To sum up, we do not consider such indemnification contracts as solid insurance contracts, for the following reasons:

- No regulation imposes indemnifiers to reserve, and if reserving were to be carried out, we do not have the information on the capital mobilized.
- Asset management companies appear not to be legitimate entities to carry out such an activity.
- When collateral assets are "risky" (e.g., riskier than sovereign bonds), the shortfall risk is material in case of security borrower's default. But they seem to assume that such risk is immaterial as if collateral was always in the form of sovereign bonds.
- The events which trigger indemnification and the exact nature of indemnification is sometimes unclear.

2.1.3 Risk management policies specific to swap exposures

In Europe, OTC Derivatives are regulated by Regulation n° 648/2021 on OTC derivatives, central counterparties and trade repositories, known as European Markets Infrastructure Regulation (EMIR). It came into force on 16th August 2012, and applies to any financial or non-financial entity involved in a derivative contract.

The main obligation in EMIR regulation is the central clearing obligation which was enforced in June 2016. Under this obligation, the value of a derivative position must be marked to market on a daily basis and the resulting value of the derivative contract must be brought down to 0 via a margin call i.e. the derivative value must be "reset". When central clearing is not applied on a trade, it is possible since March 2017 to manage counterparty risk of such exposures through initial and variation margins. In effect the derivative value is collateralized.

Let us review the two options in the case of a two-leg swap:

- When a reset occurs:
  - For a positive swap value, the ETF receives cash from the swap counterparty and buys securities (or receives securities ownership), so that substitute basket value is brought up to the NAV. The swap nominal is increased by an identical amount, and the swap value is brought down to 0.
  - For a negative swap value, the ETF sells securities and transfers proceeds to the swap counterparty so that the value of the substitute basket is brought down to the NAV. The swap nominal is decreased by an identical amount, and the swap value is brought up to 0.
- When swap value is collateralized, the swap counterparty posts collateral against the swap value if it is positive or the ETF posts collateral to the swap counterparty if it is negative.

In both cases, counterparty risk is removed, but:

- with the reset, a pure two-leg swap set up is maintained
- with collateralization of swap value, part of the fund's assets is a collateralized receivable similar to the one in the single leg swap.

2.1.3.1 Lending of securities in the substitute basket

In the two-leg swap set up, lending of securities from the substitute basket is rarely implemented. iShares and XTrackers ETFs do it for some of their ETFs. Securities are usually lent to one of the swap counterparties. As this practice is very rare we ignore it in this memoir.

2.1.3.2 Swap "reset" rules

Each provider sets its own rules to reset the swap value, which are summed up in Table 7:

Table 7: Frequency or modalities of swap reset triggers, by provider

Provider	Frequency/trigger
Amundi	Daily
BNPPAM	When there is a creation or redemption of shares
Invesco	Whenever any of the following criteria are met: 1. Exposure to a swap counterparty exceeds any of the following: 400,000 EUR or 0.20% of fund's assets or 4.5% of swap notional 2. There is a creation or redemption (only on impacted swap) 3. 30 days have passed since last reset
Lyxor	Daily
UBS	1. When the swap value by counterparty exceeds 8% of the ETF's NAV 2. On a quarterly basis 3. At any day agreed by both counterparties
XTrackers	1. When there is a subscription or redemption (on impacted swap) 2. On termination of the respective swap agreement (entire swap).

Source: ETFs providers annual reports and marketing documents

To provide money to investors reedeming their shares the ETF can decrease the swap notional by the percentage redeemed, which calls for a reset on the impacted notional to get the full amount of securities to be sold. All synthetic ETFs providers abide by this rule and this is the reason why redemptions are a frequent trigger to swaps reset among providers indeed. In such a set up counterparty risk remains unchanged for remaining investors in the ETF.

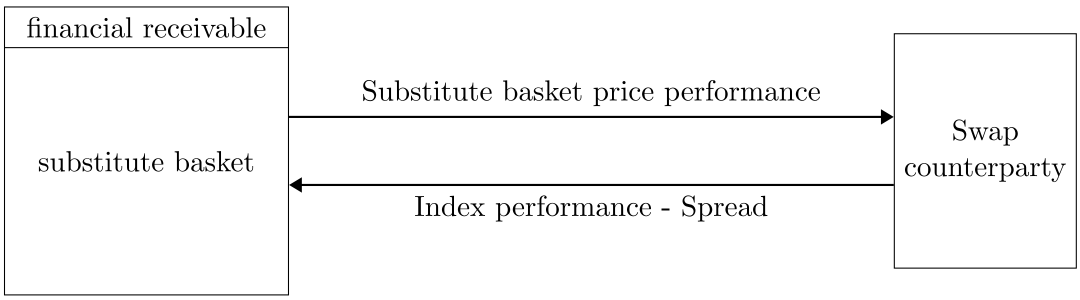
XTrackers, UBS AM and Invesco's synthetic ETFs reset the fraction of the swap impacted by subscriptions and redemptions, while the rest of the swap might be reset at a lower frequency. For instance, the rest of the swap is reset every month for Invesco ETFs and only at termination of the swap contract for XTrackers ETFs. The case of UBS AM is not different, but the set up is specific. UBS AM synthetic ETFs employ a hybrid synthetic set up. Each UBS AM synthetic ETF invests up to 5% of its assets into a single-leg swap and the rest into a two-leg swap. The portion invested in a single leg swap is used to manage subscriptions and redemptions in the fund. In effect, when there is a redemption, the collateralized cash loan embedded in the single leg swap is partly repaid by the swap counterparty to the ETF. The swap notional not concerned by redemptions is often reset every quarter or when the collateralized value by counterparty goes above 8% of the ETF NAV.

Inbetween, BNPPAM synthetic ETFs reset an ETF's swap each time there is a subscription or redemption. This is done to ensure that the swap market value does not exceed 10% of the fund's assets.

At last, Lyxor and Amundi reset the entire swap value at a daily frequency. This might be commanded by a high turnover in their ETFs' assets, due to frequent subscriptions and redemptions.

To sum up, for many providers, the proportion of the swap notional not concerned by subscriptions and redemptions is not reset on a daily basis such that it is collateralized. This means that the two-leg swap model used by such providers is likely to migrate towards a hybrid set up, as shown in Figure 7 where the financial receivable represents the collateralized swap value:

Figure 7: The two-leg swap set up with collateralized swap value



EMIR allows for the collateralization of swap values by as much as 10% of the ETF NAV by swap counterparty. This is consistent with our findings whereby for many providers having recourse to multiple swap counterparties , the collateralized swap value of some synthetic ETFs has sometimes reached a substantial proportion of the ETF NAV during the period 2017-2021.

2.1.3.3 Management of swap counterparties

Synthetic ETFs' exposure to swap counterparties is in practice less diversified than physical ETFs exposure to securities lending counterparties. ETFs providers such as Invesco, BNPPAM, Lyxor and XTrackers strive to diversify swap counterparties exposure. Synthetic ETFs from other providers often have a single counterparty. UBS acts as the sole swap counterparty for UBS synthetic ETFs, Deutsche Bank acts as the sole provider for XTrackers Fixed Income ETFs, BNP Paribas is the sole swap counterparty for Amundi Fixed Income ETFs and Société générale is the sole swap counterparty for Amundi Equity ETFs.

In case of default of a swap counterparty, there are "novation" processes meaning ETFs providers replace them by another counterparty to guarantee continuity of index replication.

To sum up, there is some diversity in the management of securities lendings and swap set ups of ETFs providers. This diversity might translate into a dispersion in ETFs' SCR Counterparty. In the next section, we delve into the rules for the calculation of both SCR Market and Counterparty.

2.2 Application of SCR Market and SCR Counterparty to direct investments and SFTs used by ETFs

In this section, rather than simply enumerating the different risk modules, we explain how we proceed to implement them on our dataset and this is the reason why risk submodules which do not show up in our dataset are not discussed here. Those risk submodules apply to direct investments as well as indirect exposures (CIUs, derivatives), except for the SCR concentration submodule which applies to direct investments only.

2.2.1 Market Risk exposures and SCR submodules

We have seen in introduction that market risk stems from the variation in financial assets' prices, and that market risk is treated with an asset class approach, via 6 risk submodules. Property Risk will not be reviewed here as no ETF is subject to that module in our database.

2.2.1.1 Equity SCR

Equity risk stems from variation in equity prices or their volatility. Equity SCR is covered in articles 168 to 173. It groups equities into 3 types: type I equity (a stock listed on a regulated market in any country of the OECD or the European Economic Area - EEA), type II equity (a stock listed in a country not from EEA or OECD, or a private equity) and infrastructure equities.

Shocks to apply to the market value of each equity type are summed up in Table 8 below:

Table 8: Equity SCR shocks

	type I	**type II**	**Infrastructure**
Strategic investments	22%	22%	22%
Other investments	39% + SA	49% + SA	30% + 0.77 ×SA

Strategic investments refer to shares of companies held with a long term perspective.

In Table 8, SA stands for "Symmetric Adjustment", which adjusts the SCR requirement by taking into account the trailing path of the equity market price, and is detailed below:

$$SA = \frac{1}{2} \times (\frac{CI - AI}{AI} - 8\%). \quad (2)$$

AI is the 36-month trailing average reference index value

CI is the current reference index value

SA is used to increase or decrease Equity SCR by comparing the current level of the stock price to its most recent trajectory. In essence it is a mechanism to reduce procyclicality in SCR Equity requirements. It cannot exceed 10% in absolute value. This "dampener" depends on a reference index which is supposed to be representative of equity portfolios of a group of European insurance companies. SA will be ignored in our calculations. As we are interested in comparing SCRs values for similar ETFs and their indices, SA component in the SCR Equity is expected to be identical for all similar ETFs and indices. Adding SA in our calculation is not expected to modify the hierarchy in the compared values.

We denote $\boldsymbol{SCR_{Equity}}$ as the product of the weights of each equity type in a given portfolio, times the corresponding SCR Equity shocks. Then the Equity SCR of a given insurer is given by $SCR_{Equity} = \sqrt{\boldsymbol{SCR_{Equity}}'.\boldsymbol{\Sigma}_{Equity}.\mathbf{SCR_{Equity}}}$, with $\boldsymbol{\Sigma}_{Equity}$ the correlation matrix across the different types of Equity shocks in the SF:

$$\boldsymbol{\Sigma}_{Equity} = \begin{array}{l} \\ \textbf{Type I} \\ \textbf{Type II} \\ \textbf{Infrastructure} \end{array} \begin{array}{c} \begin{array}{ccc} \textbf{Type I} & \textbf{Type II} & \textbf{Infrastructure} \end{array} \\ \begin{pmatrix} 1 & 0.75 & 0.75 \\ 0.75 & 1 & 1 \\ 0.75 & 1 & 1 \end{pmatrix} \end{array}$$

Equity shocks are not very granular in the SF. For instance, the size or the liquidity of a company, to which stock price volatility is significantly correlated, is not taken into account. As a result, ETFs which sample their portfolios towards Large Capitalization or "Value" Stocks (whose market prices are less volatile) do not benefit from a lower SCR for instance.

2.2.1.2 Interest Rate SCR

Interest Rate risk is the risk incurred by assets (or liabilities) from their sensitivity to changes in the interest rate curve or interest rate volatility. It concerns mainly public and private sector bonds, bills, and securitizations. It is covered in Articles 165 to 167.

To compute sensitivity to interest rates, the insurance company has to use the risk-free discount rates published by EIOPA on a monthly basis. They are based upon a spot rate curve whose parameters are calibrated with market rates using the Smith Wilson model. The market rates are swap rates where there is a sufficiently deep and liquid swap market, or government bond rates otherwise. Risk-free yield curves are published for each of the key currencies within the EU insurance market. Upward and a downward shocks for the entire term structure are also published by EIOPA and have to be applied to this curve. An upward rate shock must be worth at least 100 bp in absolute terms. No downward shock is applied to negative rates. Cash flows of each relevant instrument are first discounted using the initial spot rate curve and then using the shocked curves, to obtain their stressed value, and eventually their variation in market value for each shock. The IR SCR is given by the worst of these two variations.

To begin with, cash flows of the fixed income instruments must be projected, but as we handle a very large number of bonds, this is a very data and environment-consuming exercise indeed. As we have the duration of all bonds in our dataset, we approximate the variation in value of any given bond as the product of the bond initial value times the upward shock in rates times the bond duration. Discounting the cash flows of each bond would have changed only slightly the results indeed. We use the upward rate shock as it has the highest amplitude among the two.

This approximation is valid for vanilla bonds, but has drawbacks when it comes to bonds with embedded options, such as callable, putable or convertible bonds. The cash flows and the maturity of such products can be modified following a rate shock. This is why we use option adjusted durations for our calculations.

As the EIOPA curve is only available at a monthly frequency, we get the curve at the date closest to the reporting dates of our dataset. In addition, as only key maturity tenors are available in the EIOPA dataset, we calculate a theoretical rate for all existing bond maturities using linear interpolation. In addition, as the first tenor available in the EIOPA dataset is the 1-year tenor, we apply linear extrapolation to get spot rates below 1 year.

2.2.1.3 Spread SCR

Spread risk is the risk incurred by assets (or liabilities) from their sensitivity to changes in credit spread or credit volatility with respect to the risk free interest rate curve. It has to be applied to bonds and loans (corporate bonds, covered bonds), securitizations and credit derivatives not used for hedging. It is covered by articles 175 to 180.

The shock to be applied to an instrument to get its SCR Spread depends on its credit quality and its modified duration. The credit quality is measured by the Credit Quality Step (CQS), which is a rating scale of 7 notches ranging from 0 (best quality) to 6. It is a translation of ratings provided by rating agencies, referred to in the text as External Credit Assessment Institutions (ECAIs). The correspondence between CQSs and ratings from ECAIs is provided in the Commission Implementing Regulation (EU) 2016/1799 of 7 October 2016 laying down implementating technical standards with regard to the mapping of credit assessments of external credit assessment institutions for credit risk in accordance with Articles 136(1) and 136(3) of Regulation (EU) No 575/2013 of the European Parliament and of the Council.

There are 26 ECAIs listed in Regulation No 575/2013, but as we already mentioned, Bonds and Securitizations are mostly rated by ECAIs such as Moody's, S&P, Fitch and DBRS, which are the four ECAIs retained in this memoir. The correspondence table between their range of ratings and CQSs is provided in Table 9:

Table 9: Correspondence matrix between credit ratings and CQSs

Rating agency \ **CQS**	0	1	2	3	4	5	6
Fitch	AAA	AA	A	BBB	BB	B	$\leq B$
Moody's	Aaa	Aa	A	Baa	Ba	B	$\leq B$
S&P	AAA	AA	A	BBB	BB	B	$\leq B$
DBRS	AAA	AA	A	BBB	BB	B	$\leq B$

A CQS must be based on the second best rating from at least 3 ECAIs. If only two ratings are available, the worst rating will be used, and if only one rating is available it will be retained. The choice of ECAIs cannot be changed over the life of an instrument, and must be the same for similar debts.

Bonds and loans ratings of the instruments held by ETFs are in practice more granular than the ratings from Table 9. For instance, ratings are often accompanied by rating outlook or rating sollicitation. As the correspondence table does not take them into account, they are removed each time they are present before conversion into a CQS.

In our database, fixed income instruments held by ETFs are classified according to the Bloomberg BCLASS system mentioned in the data section. The classification looks close to the Solvency II classification but is not identical though. A correspondence table between BCLASS categories and Solvency II product categories has to be built.

SCR Spread is declined into SCR Bond, SCR Securitization and SCR Credit derivatives. As we do not handle the latter in our database, we do not detail the corresponding SF.

- **SCR on bonds and loans ("SCR Bonds")** is covered in articles 176 and 180. Article 176.3 covers the general case for rated bonds, while articles 176.4 and 176.5 cover calculation for unrated collateralized and unrated uncollateralized bonds. Article 180 covers "specific exposures". Specific exposures refer to: i. covered bonds (180.1), ii. bonds which are exempt from SCR Spread (180.2) and iii. sovereign bonds not issued by member states but made out in their own currency (180.3). Bonds covered by article 180.2 are bonds issued by the ECB, by governments and central banks of member states provided they issue in their own currency, by multilateral development banks and international organizations and by local authorities. Bonds fully guaranteed by any of the above entities are also included.

  i. We start by isolating those bonds entitled to a SCR Bond of 0 in Article 180.2:

  - **Bonds issued by International and Multilateral Development Banks and International Organizations** are given in articles 117 and 118 of Regulation (EU) No 575/2013 of the European Parliament and the Council (26 June 2013) on prudential requirements for credit institutions and investment firms. Qualifying entities are given in the form of a list. All issuance currencies are accepted. For instance, a Bond issued in NZD by the Nordic Invesment Bank (an international development bank based in Helsinki) attracts a SCR Bond of 0.
  - **Local authorities considered as specific exposures** can be found in the Final report on public consultation No. 14/057 on implementing technical standards with regard to the list of regional governments and local authorities, exposures to whom are to be treated as exposures to the central government (EIOPA-Bos-15/119, 30 June 2015). Such entities receive a SCR Bond of 0 provided their names is present

in the list of regional governments and local authorities given in that text. For instance, in Austria, any regional government or local authority shall be treated as an exposure to the central bank of the jurisdiction provided it is referred to as "Land" or "Gemeinde".

– **Sovereign bonds issued by member states** are bonds made out in EURO for euro area countries issuers and bonds made out in their national currency for member states not in the euro area (e.g., CZK for Czech Republic).

When then handle other specific exposures listed in Articles 180.1 and 180.3:

ii. Covered bonds receive a SCR spread as defined in Article 180.1 (see Table 10). As BCLASS categories are not strictly identical to the ones of Solvency II, some bonds defined as covered bonds in the BCLASS classification are not considered as such in Article 180.1 (for instance, covered bonds issued by a Canadian or an Australian bank). Article 180.2 states indeed that only covered bonds issued by a bank registered in a member state should be considered as such.

Table 10: Stress as a function of duration and CQS, article 180.1

Duration \ CQS	0	1
$\leq 5y$	$0.7\% \times Dur$	$0.9\% \times Dur$
$\geq 5y$	$\min(3.5\% + 0.5\% \times (Dur - 5), 1)$	$\min(4.5\% + 0.5\% \times (Dur - 5), 1)$

iii. Article 180.3 deals with bonds issued by non member states in their own currency. This would be the case for instance for a Japanese Government Bond issued in JPY. SCR Spread grid for such bonds is defined in Table 11:

Table 11: Stress as a function of duration and CQS, article 180.3

CQS		0 and 1		2		3		4		5 and 6	
Duration	*Stress*	a_i	b_i	a_i	b_i	a_i	b_i	a_i	b_i	a_i	b_i
$\leq 5y$	$b_i \times Dur_i$	-	0%	-	1.1%	-	1.4%	-	2.5%	-	4.5%
$\in]5y, 10y[$	$a_i + b_i \times (Dur_i - 5)$	0%	0%	5.5%	0.6%	7.0%	0.7%	12.5%	1.5%	22.5%	2.5%
$\in]10y, 15y[$	$a_i + b_i \times (Dur_i - 10)$	0%	0%	8.4%	0.5%	10.5%	0.5%	20.0%	1.0%	35.0%	1.8%
$\in]15y, 20y[$	$a_i + b_i \times (Dur_i - 15)$	0%	0%	10.9%	0.5%	13.0%	0.5%	25.0%	1.0%	44.0%	0.5%
$\geq 20y$	$\min(a_i + b_i \times (Dur_i - 20), 1)$	0%	0%	13.4%	0.5%	15.5%	0.5%	30.0%	0.5%	46.5%	0.5%

iv. Bonds and loans issued by any of the previous entities but not fulfilling all previous criteria of article 180 shall be covered by Article 176.3, and will attract a SCR Bond following the criteria edicted in Tables 12 to 14. It concerns non eligible multilateral development banks, local authorities not mentioned in article 180.2 (for instance, US local authorities), sovereign bonds or guaranteed bonds or local authorities bonds issued by member states in hard currency, sovereign bonds issued by non member states in hard currency or Covered Bonds not considered as such by Article 180.1 because of the nationality of the issuer. It also concerns all Corporate bonds. As a result, an Italian bond issued in USD belongs to categories of Article 176.3, and thus attracts a positive SCR Bond whereas a Czech bond issued in CZK receives a SCR Bond of 0.

Table 12: Stress as a function of duration and CQS, article 176.3

CQS		0		1		2	
Duration	*Stress*	a_i	b_i	a_i	b_i	a_i	b_i
$\leq 5y$	$b_i \times Dur_i$	-	0.9%	-	1.1%	-	1.4%
$\in]5y, 10y[$	$a_i + b_i \times (Dur_i - 5)$	4.5%	0.5%	5.5%	0.6%	7.0%	0.7%
$\in]10y, 15y[$	$a_i + b_i \times (Dur_i - 10)$	7.0%	0.5%	8.4%	0.5%	10.5%	0.5%
$\in]15y, 20y[$	$a_i + b_i \times (Dur_i - 15)$	9.5%	0.5%	10.9%	0.5%	13.0%	0.5%
$\geq 20y$	$\min(a_i + b_i \times (Dur_i - 20), 1)$	12.0%	0.5%	13.4%	0.5%	15.5%	0.5%

Table 13: Stress as a function of duration and CQS, article 176.3 (continued)

CQS		3		4		5 and 6	
Duration	*Stress*	a_i	b_i	a_i	b_i	a_i	b_i
$\leq 5y$	$b_i . Dur_i$	-	2.5%	-	4.5%	-	7.5%
$\in]5y, 10y[$	$a_i + b_i \times (Dur_i - 5)$	12.5%	1.5%	22.5%	2.5%	37.5%	4.2%
$\in]10y, 15y[$	$a_i + b_i \times (Dur_i - 10)$	20.0%	1.0%	35.0%	1.8%	58.5%	0.5%
$\in]15y, 20y[$	$a_i + b_i \times (Dur_i - 15)$	25.0%	1.0%	44.0%	0.5%	61.0%	0.5%
$\geq 20y$	$\min(a_i + b_i \times (Dur_i - 20), 1)$	30.0%	0.5%	46.5%	0.5%	63.5%	0.5%

Table 14: Stress as a function of duration, article 176.4

Duration	*Stress*
$\leq 5y$	$3\% \times Dur_i$
$\in]5y, 10y[$	$15\% + 1.7\% \times (Dur_i - 5)$
$\in]10y, 20y[$	$23.5\% + 1.2\% \times (Dur_i - 10)$
$\geq 20y$	$\min(35.5\% + 0.5\% \times (Dur_i - 20), 1)$

- **SCR on Securitizations** is covered in articles 177 and 178. Securitizations are divided into Type I Securitizations (of highest quality), Type II Securitizations (of lowest quality) and Resecuritizations.

  Securitizations are considered as Type I if, among others, they have a CQS not below 3, they are quoted on a regulated market in EEA or OECD and they meet minimum standards on underlying assets quality and transparency. CQSs are translated into factors as shown in Table 15:

Table 15: Stress as a function of duration, article 178.1

CQS	*0*	*1*	*2*	*3*
b_i	2.1%	3%	3%	3%

Then, the stress to apply to a Type I Securitization is given by $stress_i = \min(b_i \times dur_i, 1)$.

dur_i is the modified duration of the Securitization.

Unrated securitizations receive a stress of 100%.

Some US Asset-Backed Securities (ABSs) are issued by Government Sponsored Enterprises (GSEs) such as the Federal National Mortgage Association (Fannie Mae) or the Federal Home Loan Mortgage Corporation (Freddie Mac). A GSE is a quasi-governmental entity established to facilitate borrowing for a variety of individuals. It does not lend directly but purchases loans by issuing ABSs. GSEs are private entities but they enjoy the implicit guarantee from the US Government. But the US Government guarantee is not rewarded with a particular treatment in the Delegated Regulation. Moreover, GSEs issuances are not rated, so they attract a stress of 100%.

At last, for instruments covered by article 176 and 178, spread duration is floored at 1.

Eventually SCR Spread is obtained by adding the different SCRs: $SCR_{Spread} = SCR_{Bond} + SCR_{Securitization}$.

2.2.1.4 Currency Risk SCR

Currency Risk is the risk stemming from the volatility in exchange rates. It is covered by article 188. It applies to all investments in foreign currencies (i.e., all currencies except EURO) where currency risk is not hedged. For each asset made out in a foreign currency, a shock of 25% has to be applied upward and downward. The highest loss between the two is used. However, for some currencies pegged to the EUR, the shock is of much lower amplitude than 25%. For instance, for the Danish Krona, the shock is limited to 0.39%. Eventually, SCR Currency is obtained by adding the SCR shocks in the different currencies.

2.2.1.5 Concentration SCR

Concentration risk is the risk stemming from a lack of diversification of a portfolio of assets, or from a significant exposure to the default risk of an issuer. It applies to all direct investments, i.e., either Equities or Bonds. It is calculated at the issuer level: entities which are part of the same group are considered as one single name. It is covered in articles 182 to 187.

Weighted average CQSs are first calculated among each issuer group, with weights given by market values, and weighted average CQSs rounded up. A value of 5 is given to non rated exposures. Then they are translated into relative thresholds for excess exposures as shown in Table 16 below:

Table 16: Relative thresholds of excess exposures, article 185

Weighted average of CQS on single name i	0	1	2	3	4	5	6
CT_i	3%	3%	3%	1.5%	1.5%	1.5%	1.5%

The threshold increases with the credit quality of the issuer.

Excess exposure XS of every issuer is then calculated. For issuer i it writes:

$$XS_i = max(0, E_i - CT_i \times Assets). \tag{3}$$

E_i is the exposure at risk, i.e. the sum of all direct investments in issuer i (loans, bonds, equities)
$Assets$ is the sum of all direct investments of the insurer

SCR concentration for issuer i is then computed as $SCR_{Conc,i} = XS_i \times g_i$, with g_i the risk factor applied to the single name issuer i. Risk factors are also a translation of weighted average values of CQSs and are given in Table 17.

Table 17: Risk factors for market risk concentration, Article 186

Weighted average of CQS on single name i	0	1	2	3	4	5	6
g_i	12%	12%	21%	27%	73%	73%	73%

As for the SCR Spread submodule, there are "specific" exposures in the Concentration submodule. Exposures exempted from SCR Spread are also exempted from SCR Concentration indeed. Covered Bonds with a CQS of 0 or 1 attract a value of CT equal to 15%. In addition, as for the SCR Spread, sovereign and central administrations from countries other than member states issuing in their own currency have a specific risk factor regime as shown in Table 18:

Table 18: Risk factors for market risk concentration, Article 187

Weighted average of CQS on single name i	0	1	2	3	4	5	6
g_i	0%	0%	12%	21%	27%	73%	73%

Eventually, SCRs Concentration are aggregated across all single name issuers using the following formula:

$$SCR_{Conc} = \sqrt{\sum_{i=1}^{n} SCR^2_{Conc,i}}. \tag{4}$$

As highlighted, SCR Concentration applies to direct investments only. As a result, insurance contracts, reinsurance contracts, derivative exposures other than credit derivatives and securities lending transactions are excluded from the submodule. They are covered by the Counterparty Risk module (see infra).

2.2.1.6 Aggregation of SCRs market risk submodules

The 6 SCRs in the market risk module matrix are stored in the vector $\mathbf{SCR_{Mkt}}$ which is the product of weights concerned by each shock times the corresponding shocks. The Market SCR is equal to $SCR_{Mkt} = \sqrt{\boldsymbol{SCR'_{Mkt}}.\boldsymbol{\Sigma_{Mkt}}\mathbf{SCR_{Mkt}}}$, with $\boldsymbol{\Sigma}_{Mkt}$ the correlation matrix across the six submodules in the SF represented below:

	Rates	**Equity**	**Property**	**Spread**	**Concentration**	**Currency**
Rates	1	A	A	A	A	0.25
Equity	A	1	0.75	0.75	0	0.25
Property	A	0.75	1	0.50	0	0.25
Spread	A	0.75	0.50	1	0	0.25
Concentration	A	0	0	0	1	0
Currency	0.25	0.25	0.25	0.25	0	1

The value of A depends on the IR shock applied: it is equal to 0 if the shock for the IR SCR is the upward shock, and to 50% otherwise.

2.2.2 Market Risk and Counterparty Risk in Securities Financing Transactions

In this section we examine which SCR Securities Financing Transactions attract. They are concerned by Market and Counterparty risk modules. The term "SFT" is not present in the Delegated Regulation, which rather considers insurance contracts, reinsurance contracts and OTC Derivatives other than credit derivatives. Many of such contracts are often used to remove risk from the insurance company's balance sheet, thus they are referred to as **"Risk Mitigation Techniques"**. Such financial techniques can be taken into account in the calculation of the SCR Market only if they reflect the economic effect of the protections offered and if they respect the conditions edicted in Articles 209 and 210 of the Delegated Regulation.

2.2.2.1 Risk Mitigation Techniques and Market Risk "netting"

In the calculation of the SCR, insurance companies take into account risk mitigation techniques only if they satisfy the 5 following qualitative criteria as prescribed in Article 209:

- Contractual arrangements and risk transfer should be legally valid
- The insurance company should have taken any appropriate measure to ensure efficacy of the arrangement
- The insurance company should be able to follow continuously the application of the arrangement and its risks
- The insurance company should not hold any direct claim to the counterparty should it default

- There should be no double counting of risk mitigation effects

Only contractual arrangements which last for at least the next 12 months and fulfill the 5 criteria should be considered in the calculation of the SCR. If such arrangements are in place for less than 12 months but that the insurance company intends to roll them into a similar arrangement when they expire, the risk mitigation technique should be considered in the calculation of the SCR provided:

- there is a written policy on the roll
- the roll of the contract does not taken place more frequently than quarterly
- the roll does not depend on a future event out of control of the insurer
- the roll of the contract is realistic compared to previous rolls
- the risk of not being able to roll due to liquidity risk is not significant
- the risk that the roll of the risk mitigation technique increases over the next 12 months is taken into account

TRSs used by ETFs in the two-leg swap set up are not used by the ETF as risk mitigating contracts *per se*. Indeed, the primary objective of the set up is to structure the most efficient ETF. However, 2-leg swap set ups shall be considered as Risk Mitigation contracts indeed. In effect, the swap paying leg removes the market risk of the substitute basket, because it pays exactly the opposite of its performance, so that the ETF is not sensitive to the risk of the substitute basket anymore. As conditions of Article 209 are respected, 2-leg swap set ups can be considered for the calculation of the ETF's SCR.

It is also required under Article 210 that the arrangement should not create significant basis risk, i.e., the initial exposure and the contract should economically offset each other. Otherwise, SCR calculation should take basis risk into account.

One can assess whether such TRSs generate or not basis risk by examining the Tracking Error of ETFs using the 2-leg swap set up, as this is the only set up virtually concerned by basis risk. A significant basis risk should be reflected by a discrepancy between the performance of the substitute basket and the swap paying leg, and eventually a discrepancy between the performance of the ETF and its index. Tracking Errors of ETFs using a substitute basket and a 2-leg swap set up is very low (see Chapter 3), which rules out that such a set up would entail basis risk. Conditions of Article 210 are thus also always satisfied and as a result the asset and the risk mitigation technique can be netted and there is no SCR Market resulting from the combined positions.

But as we deal with TRSs, we also have a "risk taking" (also called "capital generating") element in the product. The netting of the substitute basket and the swap paying leg exposures leaves the ETF with a net position on the swap receiving leg. This is the unique exposure to market risk. But the TRS also entails counterparty risk, which we review in the next section.

2.2.2.2 Counterparty Risk SCR in Securities Financing Transactions

As mentioned, the counterparty risk module mainly takes into account the default of counterparties which is not already taken into account in the market risk concentration submodule. It is covered in Articles 188 to 215.

The counterparty default risk module distinguishes between two types of exposures:

- Type I exposures, in the form of OTC derivatives used for risk mitigation, and contracts with SPVs
- Type II exposures, in the form of credit exposures not caught by the spread risk submodule (or the type I category)

Single leg swaps are OTC Derivatives used as capital generating instruments, not risk mitigation contracts. But according to EIOPA's answer to Question ID 1177 on this issue posted on EIOPA's website, "all derivatives have to be covered in the counterparty default risk module irrespective of whether they meet the criteria in Article 208 to 215 of the Delegated Regulation or not". Then, securities lending exposures are not explicitly mentioned in the Delegated Regulation, but are introduced in some ACPR instructions and as such are subject to the Counterparty risk module as well (see infra).

We do not develop Type II exposures as ETFs' exposures subject to counterparty risk belong to type I exposures only.

Counterparty risk is measured with the **actual exposure** to each counterparty, which translates into a Loss Given Default (LGD). "Actual" exposure means netting is possible on different exposures from the same counterparty, as underlined in Article 190 of the Delegated Regulation. For instance, if an ETF has entered into two different swaps with the same counterparty, they will be netted for the purpose of calculating Counterparty SCR.

We review the elements of the LGD formula for a derivative transaction and a securities lending transaction, and provide with some examples in each case.

i. LGD on a derivative contract

The Loss Given Default on a derivative contract is given in Article 192.3:

$$LGD = \max[0, 90\% \times (Derivative + RM_{fin}) - F' \times Collateral]. \quad (5)$$

Derivative is the market value of the derivative contract
RM_{fin} is the absorption effect of the derivative on market risk
F' is a factor to represent the economic effect of the collateral arrangement in case of a credit event of the counterparty.
Collateral is the risk weighted market value of collateral.

The Loss Given Default thus represents the amount of loss in case of default of the counterparty, mitigated by the collateral and the market effects of the default.

Let us develop the different elements of the formula:

- **The Risk Mitigation element**, RM_{fin}, is covered in Article 196. It is the difference between the Market SCR of the insurer without the derivative and the Market SCR of the insurer with the derivative. Thus it is the variation in market risk induced by adding the derivative to the portfolio. A positive value of RM_{fin} means that adding the derivative reduces the SCR Market.

  A prerequisite to the calculation of the RM_{fin} component is the calculation of the Market SCR of the derivative contract, using the look through approach.
  Our interpretation is that RM should be floored at 0, as RM_{fin} was introduced to quantify the amount of risk removed by the usage of a derivative, not the quantity added.
  Thus Risk taking exposures via derivatives (for instance, buying an equity forward) do not imply a negative value of RM_{fin}, even though a default of the counterparty would leave the insurer with a lower Market SCR. Thus, for a TRS receiving the performance of US Equities and paying the performance of European Equities we have $RM_{fin} = 0$, as the US Equities Index entails the highest Market SCR and the TRS increases Market SCR as a result.

- **Collateral** is covered in Article 197. It is the Risk adjusted Market Value of collateral, i.e., the Market Value of Collateral (denoted here as MVC), net of Market Risk Adjustements (see infra).
  Collateral arrangements are considered as valid if they satisfy the four criteria of Article 214.1:

  -The collateral can be sold or acquired whenever there is the need to do so
  -The collateral is either sufficiently liquid, sufficiently rated and sufficiently stable in value (no quantitative criteria are provided here), or it is guaranteed by a third party
  -There is no material correlation between the credit quality of the security borrower and the collateral value
  -The collateral is not issued by the security borrower

If any of these criteria is not met, assets received as collateral should be worth 0.

Additional conditions are added in article 214.2 when collateral is held by a third party:

-The custodian must hold collateral in a segregated account

-The custodian must satisfy a credit quality with a least a credit quality notch of 3

-Collateral substitution can only occur with the acceptance of the insurer.

-The insurance company can seize or sell collateral assets in case of default, insolvency or bankrupcy or any other credit event linked to the custodian

-Assets held as collateral cannot be used as a means of payment or as collateral for an entity different from the insurance company

If any of such conditions are not met, $Collateral = 90\% \times (MVC - MRAC)$.

– **The Market Risk Adjustment of Collateral** (that we denote $MRAC$) is the difference between the Market SCR of the insurer including the collateral and the Market SCR of the insurer without the collateral (but still including the derivative contract):

$$MRAC = SCR^{Mkt}_{Assets+Collateral} - SCR^{Mkt}_{Assets}. \tag{6}$$

$MRAC$ is to be removed from MVC to obtain $Collateral$:

$$Collateral = MVC - MRAC. \tag{7}$$

All submodules of the Market Risk module are considered for the calculation of the market risk adjustment, in particular currency risk. Indeed, if collateral currency differs from the currency of the underlying asset of the derivative, collateral embeds currency risk. Interestingly, this also applies for collateral denominated in EURO if the underlying asset of the derivative is not made out in EURO, such that a risk adjustment should be applied on it on that ground.

– **The value of** F' is given in article 197.7. F' is a parameter to quantify the insurer's rights in case of a counterparty default. If the share of the insurer in the defaulted company is calculated by taking into account the collateral posted to the insurer, then $F' = 90\%$. Otherwise, $F' = 100\%$.

We can be now more explicit about Ampère reporting template's drawbacks. Ampère template is not based on the LGD formula. It is notably ignoring the elements RM_{fin} and F'.

ii. Illustration of the LGD on a derivative contract

We now develop the LGD formula for some main forms of the synthetic set ups (structuration, risk management). It illustrates the calculations performed in our dataset, and allows to show the sensitivity of the LGD formula to its different parameters.

Example 1

The first example is **a substitute basket combined with a two-leg swap with a single swap counterparty and a daily reset**.

Let us denote by SCR_b^m the Market SCR of the paying leg of the swap and by SCR_i^m the Market SCR of the receiving leg, obtained with the look through approach. The Market SCR of the TRS is then equal to **the difference between the Market SCR of the receiving leg and the Market SCR of the paying leg**:

$$SCR_{swap}^m = SCR_i^m - SCR_b^m. \quad (8)$$

The Market SCR of the ETF is equal to SCR_b^m without the swap and, provided conditions of article 209 and 210 are satisfied, to SCR_i^m with the swap.

- If $SCR_i^m > SCR_b^m$, the swap increases Market Risk, and $RM_{fin} = 0$.
- If $SCR_i^m < SCR_b^m$, the swap removes Market Risk, and $RM_{fin} = SCR_b^m - SCR_i^m$.

Which sums up as:

$$RM_{fin} = max(0, SCR_b^m - SCR_i^m). \quad (9)$$

As the swap is reset on a daily basis, its value equals 0, and, as a result, no collateral needs to be posted. The LGD on the swap writes:

$$LGD = max[0, 90\% \times max(0, SCR_b^m - SCR_i^m)]. \quad (10)$$

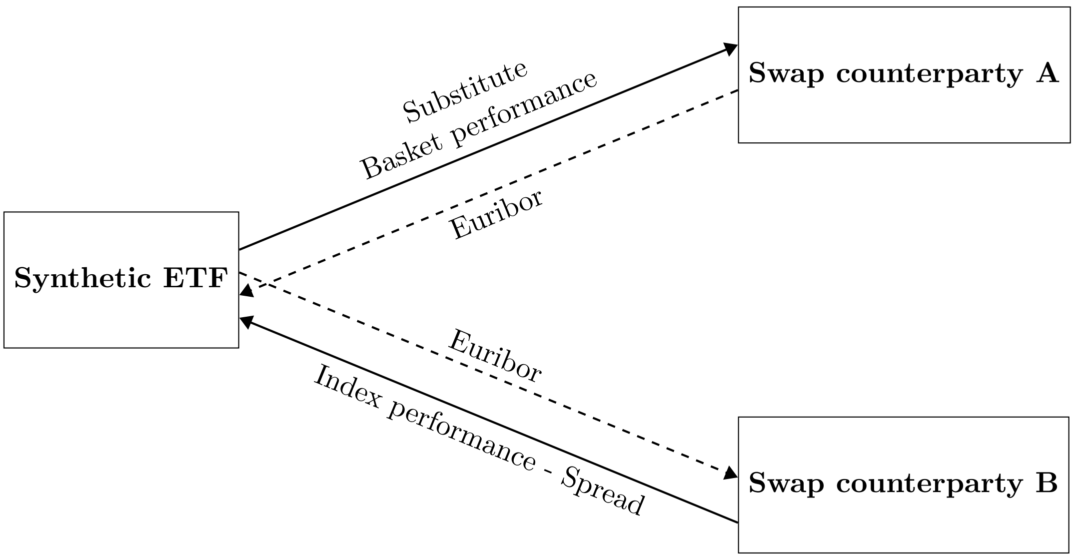
Example 2

The second example is **a substitute basket combined with a 2-leg swap with one counterparty per leg and a daily reset**.

As described in Chapter 1, one of the reasons for using the synthetic set up might be linked to regulation. For instance, a provider might be willing to launch an ETF which tracks the S&P 500 and which is at the same time eligible to the PEA in France. Such an ETF must invest at least 75% of its assets into European Equities. The provider must set up a 2-leg synthetic ETF then. In such a case, the swap counterparty must fulfill two objectives: it must be able to deliver the S&P 500 performance and it must receive the performance of the substitute basket of European Equities as well. Usually, the ETF does not request the swap counterparty to sell a specific substitute basket. Rather, the swap counterparty sells assets it already has on its balance sheet in compliance with ETFs criteria, with the lowest possible opportunity cost. A swap counterparty to a PEA eligible ETF has less leeway on the assets it sells to the ETF than a counterparty selected merely on its ability to track a given index.

This can translate into a higher swap spread paid by the ETF than if the ETF had not the PEA constraint. However, the ETF provider can decide to rely on two single leg swaps with two different counterparties, and look for the most competitive counterparty for each leg, to pay a lower aggregated swap spread than it would with a single counterparty. In this set up each single leg swap is unfunded, i.e., they do not entail a transfer of cash. This set up is not standard and quite unfrequent compared to the set ups introduced in Chapter 1 and this is the reason why it was not introduced before. It is illustrated in Figure 8 below:

Figure 8: The 2-leg swap set up with two different counterparties



As two counterparties are now involved, there are two LGDs to compute:

- Without the swap with counterparty A, the SCR Market of the ETF equals SCR_m^b and with the swap, it equals 0 provided conditions of articles 209 and 210 are fulfilled, thus $RM_{fin}^A = SCR_b^m$.
- Without the swap with counterparty B, the SCR Market of the ETF equals SCR_m^b and with the swap, it equals $SCR_m^i + SCR_m^b$, thus $RM_{fin}^B = 0$.

The swap value has a daily reset so no collateral needs to be posted as a result. The LGD per counterparty and the total LGD of the ETF then write:

$$LGD_A = max(0, 90\% \times SCR_b^m) = 90\% \times SCR_b^m. \quad (11)$$

$$LGD_B = 0. \quad (12)$$

$$LGD = LGD_A + LGD_B = 90\% \times SCR_b^m. \quad (13)$$

Example 3

The third example is **a substitute basket combined with a 2-leg swap set up with a single counterparty where the swap value is not reset but collateralized**.

Assume that $F' = 90\%$. The LGD on the two-leg swap writes:

$$LGD = \max[0, 90\% \times (Derivative + RM_{fin} - Collateral)]. \quad (14)$$

$$LGD = 90\% \times \max(0, Derivative + RM_{fin} - \frac{\alpha \times Derivative}{1-h}). \quad (15)$$

$$LGD = 90\% \times \max(0, RM_{fin} - Derivative \times \frac{\alpha - 1 + h}{1-h}). \quad (16)$$

h is the average haircut on the collateral.

α is the share of collateral (in %) meeting requirements from article 214.

- If the collateral satisfies all criteria of article 214, then $LGD = 90\% \times (RM_{fin} - Derivative \times \frac{h}{1-h})$.
- If the collateral does not satisfy all criteria of Article 214, then $LGD = 90\% \times \max(0, Derivative + RM_{fin})$.

Often, more transparency is provided on the value of the derivative than on the collateral. In such cases, we proceed as if the position was not collateralized such that collateral is assumed to be worth 0.

Example 4

The fourth example is **the case of a single leg swap with a single counterparty**. As it is a pure risk taking instrument, $RM_{fin} = 0$. Assume that $F' = 90\%$. Using the notations introduced in the previous example, the LGD writes:

$$LGD = \max[0, 90\% \times (Derivative - Collateral)]. \quad (17)$$

$$LGD = 90\% \times \max(0, Derivative - \frac{\alpha \times Derivative}{1-h}). \quad (18)$$

$$LGD = 90\% \times Derivative \times \max(0, 1 + \frac{\alpha}{h-1}). \quad (19)$$

- If the collateral satisfies all criteria of article 214, then $LGD = 0$.
- If the collateral does not satisfy all criteria of Article 214, then $LGD = 90\% \times \max(0, Derivative)$.

Exemple 5

The fifth example concerns ETFs which track a "hedged" version of an index. In such instances, the tracked index is made out in a given currency but the ETF delivers the performance of that index in another currency. In the main set up, the ETF tracks the index in its original currency and exchanges its performance against the performance of the index in another currency. A derivative contract is used to exchange the index performance in its original currency against the perfomance of the same index in another currency. There is an RM component only when the ETF exchanges the index performance in its own currency against the index performance in EURO.

iii. LGD on securities lendings transactions

As already mentioned, there is no explicit reference to securities lending transactions in the Delegated Regulation. They are mentioned only in Orientation 8 of ACPR instructions regarding the treatment of exposures subject to Market and Counterparty Risk in the SF.

In Orientation 8, the SCR requirement on securities lending depends on their accounting treatment. When securities lent remain on the balance sheet and securities received as collateral are not booked in the ETF balance sheet, one should:

- apply the relevant Market Risk submodules to the securities on loan
- include securities on loan in the calculation of the required SCR counterparty on type I exposures, while taking into account the risk mitigation effect of collateral if it is meeting all the requirements of article 214 of delegated regulation.

This translates into the following LGD formula which has been formalized in an internal note from ACPR (2016):

$$LGD = \max(0, Recoverables - Collateral). \quad (20)$$

Recoverables is the market value of the securities lent

Collateral is the market value of the securities received as collateral, provided they satisfy all criteria of article 214.

This formula is much simpler than the one for OTC Derivatives. What has been lent is subject to counterparty risk, and the collateral arrangements considered as valid under Article 214 stand for the risk mitigating element. Among others, there is no reference to parameters F and $MRAC$.

When securities lent are not anymore on the ETF balance sheet and securities received as collateral are booked instead, one should:

- apply the relevant Market Risk submodules to the securities received as collateral
- calculate the SCR Counterparty on the market value of the assets lent out, provided that in case of default assets lent out will not be recovered and assets received as collateral will not be acquired

The first point does not concern SCR Counterparty, but it is crucial as it can dramatically change the Market SCR of an ETF, especially if the proportion of the NAV on loan is substantial and if collateral asset class or currency differs from the ones of the asset lent out as well.

The second point implies that the LGD should equal the value of assets on loan. However, if collateral meets all conditions in article 214, we do not see any reason why in the event of a default of a security borrower collateral could not be considered as a risk mitigating element. Thus, when securities on loan are not anymore on the ETF balance sheet, we stick to the previous LGD formula.

iv. Illustration of the LGD on a securities lending transaction

Let us consider the first accounting treatment. The LGD per counterarty of the ETF writes:

$$LGD = max(0, MV_{assets} - \alpha \times MV_{collat}). \quad (21)$$

α is the share of collateral (in %) meeting requirements from article 214

MV_{assets} is the market value of assets lent out

MV_{collat} is the market value of collateral assets

We can develop the formula further:

$$LGD = max(0, MV_{assets} - \alpha \times \frac{MV_{assets}}{1-h}). \tag{22}$$

$$= MV_{assets} \times max(0, 1 - \frac{\alpha}{1-h}). \tag{23}$$

$$= \tau \times NAV \times max(0, 1 - \frac{\alpha}{1-h}). \tag{24}$$

h is the average haircut applied to the collateral received

τ is the share (in %) of the fund's assets lent out to the counterparty

v. From LGD to SCR counterparty

LGDs are then aggregated by single name exposures of identical probability of default.

To perform such an aggregation, we calculate the CQS of each counterparty to a security lending or derivative transaction, and as per Article 199 of the Delegated Regulation we convert them into probabilities of default using the correspondence table for Type I exposures presented in Table 19:

Table 19: Correspondence matrix between CQSs and default probabilities

CQS	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Probability of default	0.002%	0.01%	0.05%	0.24%	1.20%	4.20%	4.20%

Let N be the number of different Type I single name exposures. For each of these single names, $i \in \{1, ..., N\}$, we denote by PD_i its probability of default and by LGD_i its Loss Given Default (LGD).

Assume we have M unique probabilities of default among these single names ($M \leq N$). Let us denote by TL_j the sum of LGDs over single names with default probability PD_j, $j \in \{1, ..., M\}$.

Article 201 of the Delegated Regulation defines V_{inter} and V_{intra} as follows:

$$V_{inter} = \sum_{1 \leq i,\ j \leq M} TL_i \times TL_j \times \frac{PD_i \times (1 - PD_i) \times PD_j \times (1 - PD_j)}{1.25 \times (PD_i + PD_j) - PD_i \times PD_j}. \tag{25}$$

$$V_{intra} = \sum_{j=1}^{M} \frac{1.5 \times PD_j \times (1 - PD_j)}{2.5 - PD_i} \times \sum_{PD_j} LGD_j^2. \tag{26}$$

The variance V of the distribution of LGDs is equal to $V = V_{intra} + V_{inter}$. We denote by LGD the sum of all LGDs. As per Article 200 of the Delegated Regulation, the SCR counterparty for Type I exposures then writes:

$$SCR_{ctpy,type_I} = \begin{cases} 3 \times \sqrt{V} & \text{if } \sqrt{V} \leq 7\% \times LGD. \\ 5 \times \sqrt{V} & \text{if } 7\% \times LGD < \sqrt{V} \leq 20\% \times LGD. \\ LGD & \text{if } \sqrt{V} > 20\% \times LGD. \end{cases} \tag{27}$$

2.2.3 Introducing Excess SCR

We calculate SCRs at the ETF level, so only Market SCR and Counterparty SCR are aggregated, as ETFs do not attract a SCR under other risk modules.

The aggregation of Market and Counterparty SCRs is done using the following correlation matrix in the SF:

	Market	**Counterparty**
Market	1	0.25
Counterparty	0.25	1

As a result, the SCR we compute for ETFs equals:

$$SCR_{ETF} = \sqrt{SCR^2_{Mkt} + SCR^2_{Ctpty} + 2 \times 0.25 \times SCR_{Mkt} \times SCR_{Ctpy}}. \tag{28}$$

We then define the SCR of an ETF in excess of the SCR of its index, which we call the "Excess SCR" as:

$$SCR_{XS} = SCR_{ETF} - SCR_{Index}. \tag{29}$$

It is defined in the same spirit than the return on the ETF in excess of the return on its Index. It can be positive or negative. By definition, full replication ETFs have no Excess SCR. Excess SCR stems from sampling or from the existence of counterparty risk, which both create deviations in ETFs SCR with respect to their index.

2.3 Resulting SCRs and "Excess SCRs"

As we mentioned, computation of SCR Market for Fixed-Income ETFs and SCR Counterparty for synthetic ETFs is difficult to streamline and is data and environment consuming, so it is performed for ETFs used in the optimization program only. Conversely, we are able to compute SCR Counterparty for almost all ETFs involved in securities lending transactions. This is the reason why the content dedicated to securities lending is much more important in this section. We start by a general section on the assessment of the validity of collateral arrangements used in securities lending and OTC Derivative transactions.

2.3.1 Examination of collateral arrangements' eligibility to Article 214.1

All ETFs' collateral arrangements have been reviewed in light of the 4 criteria of Article 214.

Collateral substitution is a common practice in securities lending and OTC derivative transactions. This questions the validity of the collateral arrangement, as Article 214 accepts such a practice only under certain conditions. Securities borrowers or swap counterparties are always looking to collateralize positions at the lowest possible cost and the cheapest collateral might be different every day, such that substitutions can occur every day at their request. ETFs are concerned by such substitutions just like other market counterparties. But they usually allow their SFT counterparties to do so, such that collateral arrangements cannot be discarded on that ground.

Sufficient liquidity, credit quality and price stability of collateral and the absence of material correlation between collateral value and credit quality of the security borrower are the two criteria often not satisfied.

- For instance, Small Capitalizaton Stocks, Stocks having been taken public recently, Corporate Bonds, G7 Government Inflation-Linked Bonds and Government Strips are illiquid and do not meet the criteria of sufficient liquidity.
- Equities in general do not meet the criteria regarding the absence of material correlation with the credit rating of securities borrowers, which are all investment banks. Indeed, the credit quality of banks deteriorates during stock market downturns. Thus equity prices going down are associated with banks' credit spreads widening.
- Some collateral assets are illiquid and display a material correlation with the credit quality of securities borrowers at the same time, such as small capitalization Stocks and recently listed Stocks.

As credit ratings are a categorical variable with unfrequent changes, it is quite challenging to compute their correlation with asset prices. This is why we use as a proxy of credit ratings the Option Adjusted Spreads against Government Bonds of bonds issued by banks. Representative indices of such spreads are computed by index providers. We use the Bank of America ICE Euro Corporate Banking Index Series (for the euro area) and the Bank of America ICE US Banking and Brokerage Index Series (for the United States) for our calculations.

For the different asset classes used as collateral by security borrowers we also retrieve representative indices:

- For equities, we use the Euro Stoxx Price Return Index for the euro area and the S&P 500 Price Index for the United States.
- For sovereign bonds, we use the yields of the Bank of America ICE US sovereign bond indices and the Bank of America ICE euro area sovereign bond indices (we could have worked on prices equivalently).

- For corporate bonds, we use the yield to maturity of the Bank of America ICE Euro area Corporate Bonds excluding Financials index for the euro area and the Bank of America ICE US Corporate Bonds excluding Financials index for the United States.

Market data is available at a daily frequency and correlation coefficients are calculated over the period 1997-2021 for the euro area and the period May 1998 - December 2021 for the United States. Results are presented in Tables 20 and 21. We use indices of different ratings for the euro area, to reflect the wider range of ratings of banks acting as securities borrowers or swap counterparties to ETFs. Ratings used by the index provider are S&P ratings.

Table 20: Correlation coefficients of the euro area Banking sector credit spread by credit ratings with main asset classes in the euro area

	Equities	**Corporate Bonds excluding financials**	**Sovereign bonds**
AA Euro Banking Index	-0.40	0.25	0.14
A Euro Banking Index	-0.45	0.37	0.23
BBB Euro Banking Index	-0.53	0.39	0.27

Source: Bloomberg

Table 21: Correlation coefficients of the US Banking sector credit spread with main asset classes in the US

	Equities	**Corporate Bonds excluding financials**	**Sovereign bonds**
AA US Banking Index	-0.41	0.43	-0.05

Source: Bloomberg

For sovereign bonds, the correlation coefficient is close to 0 in the United States, and ranges from 0.14 to 0.27 in the euro area. The higher correlation in the euro area stems from the presence of some euro area countries which went under stress during the euro area sovereign crisis, and tended to be more correlated with other asset classes at that time. In any case, sovereign bonds are only weakly correlated to bank credit ratings and should be considered as worth their entire market value under Article 214.1.

For Corporate bonds excluding financials, the correlation coefficient is positive and decreases with the credit quality of the bank. The positive sign means that when the banking spread rises above its mean, the yield of the corporate bond tends to do the same, i.e., the prices of corporate bonds decrease when the credit quality of banks deteriorate. However, the value of the correlation coefficient is generally not sufficiently material to state that there is a strong correlation between corporate bonds excluding financials and banks' credit ratings.

For equities, correlation coefficient is in any case higher than 0.40 in absolute value. The sign is negative as we compute the correlation between a spread and an equity price. Thus when the bank credit spread rises above its mean, the equity prices tend to fall below their mean. Equity prices tend to fall when banks' credit quality deteriorates, and increasingly so for credit ratings of lower quality.

Following the previous analysis and the requirements of Article 214.1, we assign to equities and corporate bonds received as collateral a value of 0. We recognize that our approach is not very granular indeed, but it is done on purpose:

- For instance, we do not make a difference between a type I large capitalization stock and a type I small capitalization stock, **to be consistent with the Equity risk submodule in the Market risk module of the SF**, which assigns the same SCR to all type I Equities. While it was not penalized to tilt portfolios towards small capitalization stocks in terms of Equity SCR, it is not rewarded in terms of counterparty SCR to accept only large capitalization stocks as collateral.
- We do not either take into account the level of haircut in our study, eventhough the level of haircut required on equity collateral is the highest among asset classes. As long as at least one condition of Article 214.1 is not respected, the collateral arrangement is considered as not valid, eventhough a high level of haircut is applied on collateral.

Let us now detail the results of our SCR Counterparty calculations for securities lending transactions.

2.3.2 Securities lending

We first produce some statistics with the raw data collected in financial reports. We then disclose our methodology and assumptions for our calculations.

2.3.2.1 Percentage of NAV on loan

In table 22 we present the 40 physically-replicated ETFs with the largest share of NAV on loan over the period 2016-2021:

Table 22: 40 Physical ETFs with the largest percentage of AuMs on loan (2016-2021)

ETF	**2016 mean**	**2017 mean**	**2018 mean**	**2019 mean**	**2020 mean**	**2021 mean**	**2016-21 mean**
iShares USD T Bond 7-10 yr	85.22	85.72	88.00	36.47	80.05	-	**75.07**
iShares USD T Bond 1-3 yr	-	79.61	83.62	65.17	60.18	-	**72.06**
iShares USD TIPS	68.36	87.67	81.81	58.93	45.68	-	**68.50**
iShares UK Gilts 0-5 yr	-	60.84	49.36	43.90	81.02	-	**60.90**
iShares USD T Bond 7-10 yr C	-	51.33	75.78	84.38	46.72	-	**59.37**
iShares USD TIPS 0-5 yr	-	54.8	45.87	71.78	54.20	-	**56.92**
iShares USD T Bond 3-7 yr	-	39.44	70.18	59.64	-	-	**52.17**
iShares MSCI AC Far East ex-J Small Cap	52.68	51.93	56.65	48.87	29.03		**47.30**
iShares MSCI Japan Small Cap	-	21.40	37.33	63.16	59.89	-	**45.44**
iShares Core UK Gilts	62.29	60.01	34.56	25.32	35.03	-	**41.44**
iShares Euro Govt Bonds 7-0 yr	45.69	53.70	41.16	32.16	31.26	-	**40.25**
iShares MSCI Japan CHF Hedged		36.94	37.34	34.00	33.16	33.05	**35.10**
iShares S&P Small Cap 600	-	38.22	33.96	33.06	31.82	-	**34.43**
iShares Global Clean Energy	34.92	31.03	42.32	36.91	22.67	-	**33.41**
iShares MSCI Japan	-	23.42	36.74	33.48	34.99	-	**33.40**
iShares Germany Govt Bonds	-	17.73	30.88	26.75	31.96	56.09	**31.62**
iShares EURO STOXX Small	-	33.49	30.57	32.60	28.03	-	**30.84**
iShares Euro Govt Bonds 3-5 yr	59.42	46.14	11.91	16.41	34.58	-	**30.83**
iShares Asia Pacific Dividend	-	27.17	33.39	31.76	27.74	-	**30.42**
iShares MSCI EMU Small Cap	-	27.67	28.7	30.26	30.73	-	**29.29**
Amundi Index JP Morgan EMU Govies	-	8.25	22.69	26.88	40.37	43.65	**28.97**
iShares Euro Govt Bonds 5-7 yr	-	33.95	23.17	32.26	24.78	-	**28.54**
Amundi Index MSCI Europe	-	42.33	30.40	22.46	27.19	17.10	**27.44**
iShares Euro Inflation Linked Govt Bonds	-	45.76	45.12	11.32	2.93		**26.93**
iShares Nikkei 225	-	29.34	16.38	31.60	-	-	**26.67**
iShares FTSE 250	-	33.55	38.46	21.78	15.57	-	**26.45**
iShares Diversified Commodity Swap	-	28.76	34.6	33.59	16.16	-	**26.43**
UBS ETF MSCI Japan hedged to CHF	4.57	24.95	36.00	24.55	28.61	-	**25.66**
Amundi Prime EURO Govies	-	-	-	16.30	23.13	39.18	**25.44**
iShares MSCI Japan GBP Hedged	-	22.68	27.30	29.96	24.18	16.88	**25.31**
iShares MSCI Japan EURO Hedged	-	24.79	24.78	28.26	26.56	16.88	**25.10**
iShares USD T Bond 1-3 yr	-	23.56	30.46	22.27	-	-	**24.96**
iShares China Large Cap	-	22.38	23.93	28.93	22.9	-	**24.84**
iShares Global Infl. Linked Govt Bonds	-	40.5	26.26	13.94	17.46	-	**24.54**
iShares Euro High Yield Govt Bond	-	21.87	27.66	23.39	20.16	-	**23.47**
UBS ETF MSCI EMU Small Cap	17.22	20.40	29.19	24.37	23.23	-	**23.40**
Invesco US T Bond 7-10 yr	-	-	-	23.20	24.71	-	**23.95**
iShares Euro Govt Bonds 15-30 yr	18.83	35.66	33.45	15.65	10.80	-	**23.33**
SPDR MSCI Europe Small Cap	-	24.18	24.29	22.50	23.01	21.66	**23.30**
UBS ETF Solactive Global Oil Equities	20.08	22.93	24.73	-	-	-	**23.08**

Source: ETFs' providers' annual reports

Consistent with the securities lending limits established by the different providers described in Chapter 1, we observe that the percentage of NAV on loan can reach substantial levels, and with much stability through time.

2.3.2.2 Composition of the collateral basket

In Table 23, we show the proportion of Investment Grade (IG) Bonds in the collateral basket of iShares, UBS, SPDR, Amundi and XTrackers ETFs, since 2016, at a semi-annual frequency. IG Bonds are bonds with the highest ratings and are considered as assets of the highest quality.

Table 23: Yearly average share of IG Bonds in collateral received by provider

Provider	**Mean 2016**	**Mean 2017**	**Mean 2018**	**Mean 2019**	**Mean 2020**	**Mean 2021**	**Mean 2016-21**
Amundi	NA	47.59%	60.11%	53.29%	54.43%	57.06%	**54.99%**
iShares	14.01%	26.99%	37.54%	35.27%	40.86%	34.22%	**35.57%**
SPDR	NA	22.19%	53.94%	66.45%	47.81%	24.33%	**44.75%**
UBS	14.30%	24.47%	45.87%	44.57%	41.40%	NA	**32.96%**
XTrackers	NA	99.11%	44.40%	60.64%	57.17%	NA	**64.90%**

The practice of lending an IG Bond against a security of lower credit rating or a more volatile asset class such as equity was introduced in the first chapter as ”collateral downgrade”. In Tables 24 to 26, we show the proportion of IG Bonds in the collateral basket across providers for bonds and for equities ETFs. Thus we can illustrate to which extent collateral downgrade is implemented by ETFs. Averages are calculated as simple averages, not weighted by ETFs AuMs.

Table 24: Collateral split by asset class by provider and by ETF category

Provider	IG Bonds as a % of collat - 2016			IG Bonds as a % of collat - 2017		
	Bonds ETFs	*Equities ETFs*	*All ETFs*	*Bonds ETFs*	*Equities ETFs*	*All ETFs*
Amundi	NA	NA	NA	23.07%	53.72%	47.6%
iShares	19.85%	11.96%	14.00%	41.22%	19.16%	27.00%
SPDR	NA	NA	NA	-	22.20%	22.20%
UBS	-	14.30%	14.30%	-	25.01%	24.47%
XTrackers	NA	NA	NA	-	99.11%	99.11%

Table 25: Collateral split by asset class by provider and by ETF category

Provider	IG Bonds as a % of collat - 2018			IG Bonds as a % of collat - 2019		
	Bonds ETFs	*Equities ETFs*	*All ETFs*	*Bonds ETFs*	*Equities ETFs*	*All ETFs*
Amundi	55.86%	61.25%	60.11%	52.53%	53.56%	53.29%
iShares	55.20%	29.32%	37.53%	58.53%	22.55%	35.27%
SPDR	-	53.94%	53.94%	-	66.45%	66.45%
UBS	-	46.60%	45.87%	-	45.08%	44.57%
XTrackers	-	43.55%	44.4%	-	61.19%	60.64%

Table 26: Collateral split by asset class by provider and by ETF category

Provider	IG Bonds as a % of collat - 2020			IG Bonds as a % of collat - 2021		
	Bonds ETFs	*Equities ETFs*	*All ETFs*	*Bonds ETFs*	*Equities ETFs*	*All ETFs*
Amundi	48.34%	57.30%	54.43%	56.50%	57.39%	57.06%
iShares	69.01%	27.92%	40.86%	77.58%	22.00%	34.21%
SPDR	-	47.81%	47.81%	-	24.33%	24.33%
UBS	-	42.5%	41.41%	NA	NA	NA
XTrackers	-	56.50%	57.17%	NA	NA	NA

The share of IG Bonds in the collateral basket is variable through time and for some Bonds ETFs it can be close to 0.

2.3.2.3 Available data and assumptions for SCR Counterparty calculation

Available collateral data is not homogeneous across providers:

- For Amundi, UBS, SPDR and XTrackers ETFs, collateral by ETF is displayed at the security level in financial reports. Following the previous analysis, securities issued by Sovereign and Supranational entities are considered as worth their market value while other securities are usually considered worthless under Article 214.1, as they do not satisfy liquidity, quality and stability criteria, as well as correlation with borrower credit risk.
- iShares provides collateral split only by asset class in its financial reports. Collateral is split between IG Bonds, Equities, UCITS and non-UCITS funds. IG Bonds only are considered as worth their market value as they are the only asset class satisfying all criteria of Article 214.1. Other assets are considered worthless.

For all providers, collateral by ETF is never disclosed at the security borrower level, but only at the ETF aggregated level. So we allocate eligible collateral to each counterparty, proportionnally to their share in the securities lending activity of the ETF. By doing so we assume homogeneity of collateral posted across borrowers.

2.3.2.4 Distribution of Counterparty SCR from securities lending

SCR Counterparty is expressed as a proportion of the NAV. Some descriptive statistics about SCR counterparty from securities lending across providers are given in Table 27. In this table we compute some statistics on all 2,503 observations covering 402 unique ETFs over the 2017-2021 period.

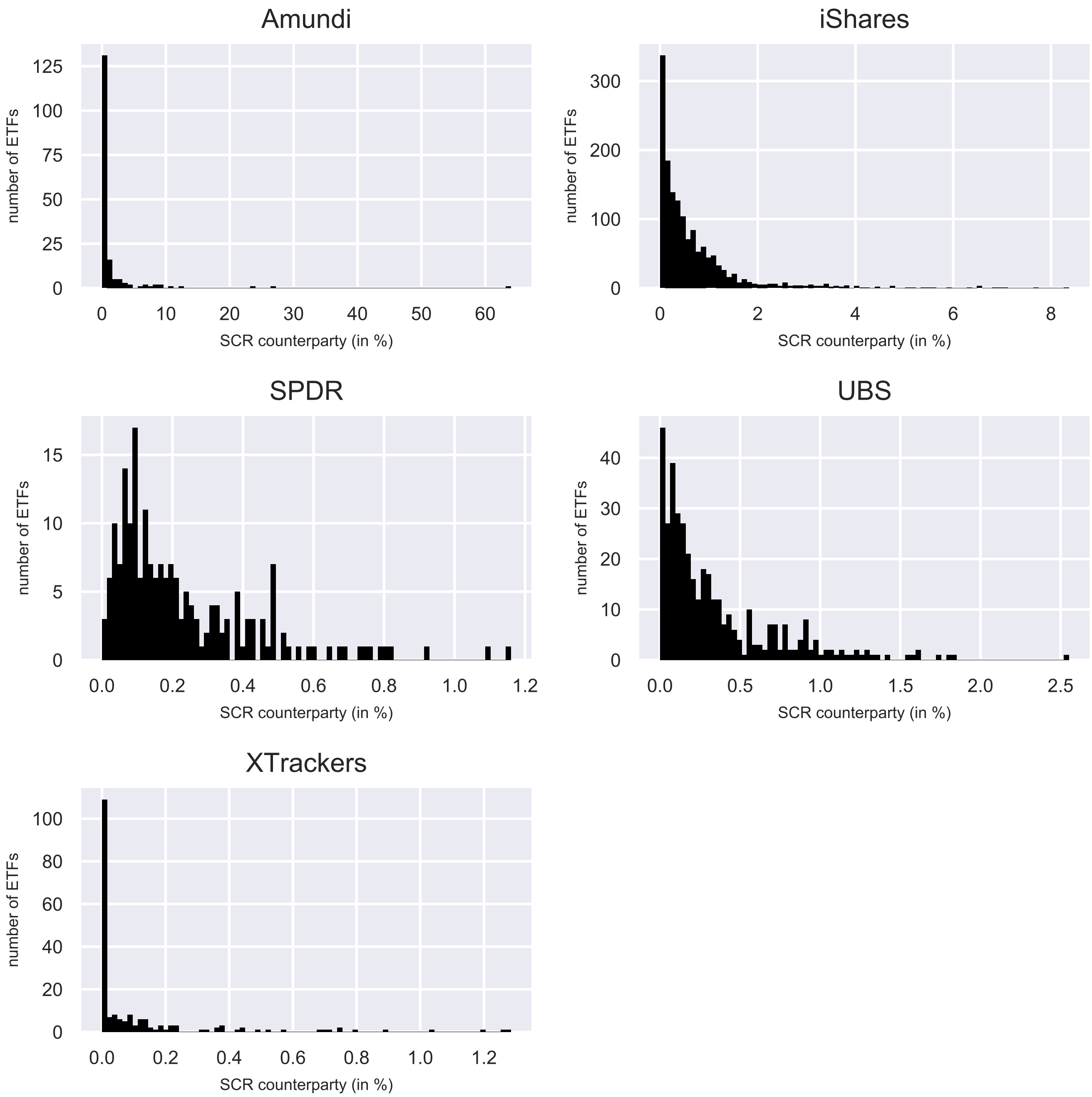
Table 27: Descriptive statistics by provider on SCR counterparty for 402 physical ETFs lending securities over the period 2017-2021, as a % of the NAV

Provider	**Number of ETFs**	**Number of observations**	**Mini -mum**	**Maxi -mum**	**Median**	**Mean**	**Standard Deviation**
Amundi	39	175	0	64%	0.24%	1.64%	5.80%
iShares	233	1,483	0	8.36%	0.38%	0.67%	0.95%
SPDR	22	195	0	1.16%	0.16%	0.23%	0.21%
UBS	74	392	0	2.55%	0.21%	0.34%	0.38%
XTrackers	33	195	0	1.28%	0.004%	0.11%	0.23%

The distribution of the SCR Counterparty of Amundi's ETFs has a few extreme values. There are two main original reasons for this. First, securities lending activity used to be frequently under collateralized during the period 2017-2018. Second, securities borrowers' identity can be missing, and in such cases we assume that such counterparties have a CQS of 6.

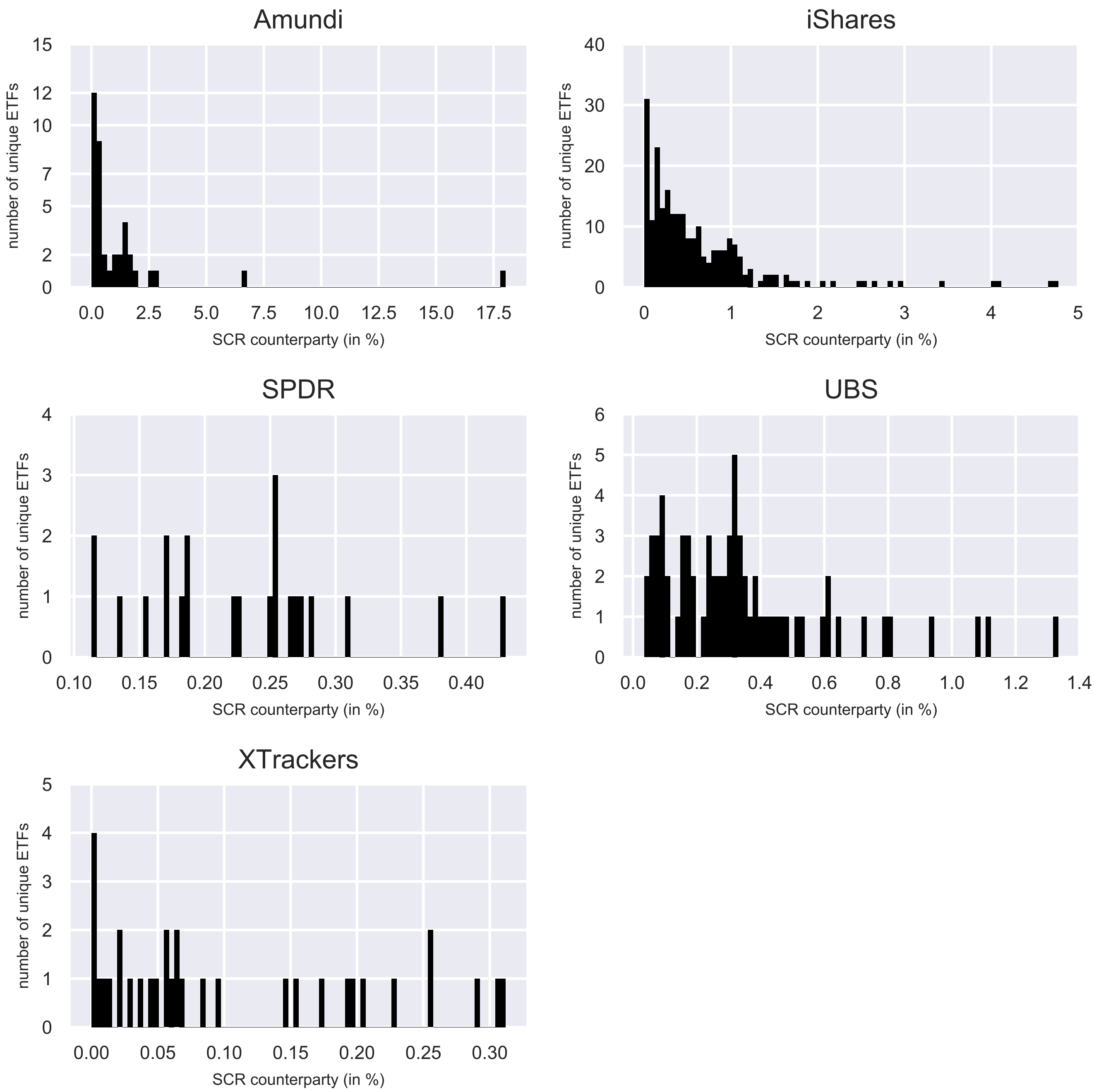
In Figures 9 we represent a series of histograms by provider of the values of the SCR counterparty due to securities lending, for the 2,503 observations.

Figure 9: SCR Counterparty over the 2016-2021 period by provider for all ETFs' observations



In Figure 10 we represent a series of histograms by provider of the average values through time of the SCR counterparty due to securities lending, for the 402 unique ETFs.

Figure 10: Average SCR Counterparty by ETF over the 2016-2021 period, by provider



2.3.2.5 Suggested improvements for the calculation of the LGD on securities lending transactions

Some refinements could be envisaged for future research, regarding the calculation of SCR Counterparty related to securities lending transactions:

- **Consider correlation between assets lent out and collateral received**: In application of Article 214, a value of 0 is assigned to equity collateral. While this seems univocal for Bonds ETFs which proceed to collateral downgrade to assign a value of 0 to equity collateral, there are situations where equity ETFs lend securities against equity collateral, and no downgrade happens. In case of a security borrower's unability to return equities on loan, the risk of loss for the ETF could be reduced if collateral acts as a good "proxy" of securities lent. A model should assess the capacity of collateral to move in sympathy securities on loan in case of a security borrower's default. This idea has been developed by Hurlin et al (2019). They propose a model to build an optimal portfolio of collateral that aims to protect investors against counterparty risk. In their model the investor's expected utility is defined as a decreasing function of the collateral shortfall. The collateral shortfall eventually depends on the difference in return between securities on loan and collateral. To sum up, when an insurance company is transferring market risk, there is to some extent a degree of correlation between assets lent and collateral received, which could be taken into account to assess the validity of the collateral arrangement.

- **Add a capital charge when redemption implies recall risk**: Some ETFs lend their the bulk of their assets or the bulk of certain securities. This implies that redemptions can trigger recall of securities on loan, i.e. redemptions can trigger recall risk. This could call for an additional capital charge.

- **Delve into indemnification contracts**: More information could be gathered on each indemnification contract on the default of the security borrowers. Some contracts might be considered solid enough and could be modelled as insurance or reinsurance contracts. They might also be considered as a guarantee in the value of the collateral, which is one criteria for the validity of collateral arrangements under Article 214.1.

- **Ensure consistency of treatment between OTC Derivatives and securities lending transactions**:

  The consistency between the SCR counterparty on a securities lending transaction and an OTC derivative transaction could be studied, as both transactions have a close financial relationship.

  The parameters of the LGD formula on derivatives could also be applied on the LGD on securities lending transactions.

2.3.3 Swaps

Fixed Income ETFs are almost exclusively physical, such that synthetic ETFs are mainly Equities ETFs, thus they track asset classes with the highest SCRs. Synthetic ETFs' substitute baskets are thus often less risky than the indices tracked by such ETFs, and at worst they closely resemble the index. This is why the risk mitigating component of swaps is often equal to 0, except for BNPPAM ETFs, as the set up is split into 2 single leg swaps, with one leg effectively transferring the market risk of the substitute basket. For Invesco, UBS AM and XTrackers ETFs, swap reset is not applied every day to the whole ETFs, so part of the funds' assets are not made out of securities but of collateralized swap values. As we do not have access to the collateral for the concerned Invesco and XTrackers ETFs, we consider it to be worth 0. For UBS AM ETFs, collateral is disclosed and it is entirely made of G7 Goverment securities and as a result the LGD of such ETFs is worth 0. At last, Lyxor and Amundi's synthetic ETFs reset swaps on a daily basis so they have virtually no SCR Counterparty. We present in Table 28 below some elements of the LGD, and eventually Excess SCR for some synthetic ETFs used in the optimization program:

Table 28: LGD components, SCR Counterparty and Excess SCRs for a sample of synthetic ETFs, average values over 2016-2021, as a % of the NAV

ETF	**RM**	**Swap value**	**LGD**	**SCR counterparty**	SCR_{XS}
BNPPAM S&P 500	17.80	0	17.00	1.03	0.27
BNPPAM Stoxx Europe 600	17.31	0	16.55	0.94	0.25
XTrackers Global Aggregate	0	19.73	19.73	2.90	1.25
XTrackers MSCI EM	0	8.68	8.68	1.00	0.26
XTrackers MSCI World	0	11.86	11.86	0.85	0.22
XTrackers S&P 500	0	14.67	14.67	1.08	0.29
Invesco Stoxx Europe 600	0	3.00	3.00	0.16	0.04
Invesco S&P 500	0	4.88	4.88	0.31	0.08
Invesco MSCI World	0	6.27	6.27	0.32	0.15
Invesco MSCI Europe	0	10.07	10.07	0.61	0.16
Invesco MSCI EM	0	14.92	14.92	0.91	0.24
Invesco Euro Stoxx 50	0	13.07	13.07	0.68	0.18

2.3.4 Sampling

Sampling concerns both bonds and equities ETFs. However, as pointed out previously, SCR Equity is not very granular, as it only makes a distinction between type I Equity, type II Equity and Infrastructure Equity. For instance, stock characteristics such as market capitalization or liquidity are not taken into account. SCR Market of full replication Equity ETFs and sampled Equity ETFs are expected to diverge only marginally from the SCR of the tracked index, possibly due to an increased concentration in the portfolio if sampling dramatically reduces the number of securities, or if securities outside of index universe are purchased.

Conversely, for Fixed Income ETFs, SCR IR and SCR Spread formulas are very granular and sampled Fixed Income ETFs tracking a given index are expected to display a higher dispersion in their SCRs. Table 29 below displays SCRs of Fixed-Income ETFs used in the optimization exercise. It splits SCR into its different SCRs risk submodules. SCR Counterparty from securities lending is also displayed, using results from the first section. Sampled ETFs indeed often lend securities. One Fixed Income ETF in our database is synthetic, so we add it to this table, so as to provide with a complete picture of Fixed Income ETFs' SCRs.

Table 29: SCR Market and SCR Counterparty of a sample of Fixed Income indices and their replicating ETFs, 17th February 2021

Provider	**# comp.**	**SCR IR**	**SCR Spread**	**SCR FX**	**SCR Conc**	**SCR Mkt**	**SCR Ctpty**	**Total SCR**
€ Gov Bonds	434	8.70%	-	-	-	**8.70%**	-	8.70%
iShares	408	8.72%	-	-	-	**8.72%**	0.648%	8.91%
SPDR	412	8.69%	-	-	-	**8.69%**	-	8.69%
Vanguard	392	8.59%	-	-	-	**8.59%**	-	8.59%
BNPPAM	173	8.83%	-	-	-	**8.83%**	-	8.83%
€ Gov I-L Bonds	36	8.24%	-	-	-	**8.24%**	-	8.24%
iShares	41	8.25%	0.00657%	0.08%	-	**8.27%**	2.19%	9.15%
XTrackers	36	8.19%	-	-	-	**8.19%**	-	8.19%
€ Agg Corp Bonds	3,139	5.23%	9.22%	-	-	**10.61%**	-	10.61%
SPDR	2,590	5.33%	9.41%	-	0	**10.82%**	-	10.82%
iShares	3,121	5.28%	9.32%	-	0	**10.72%**	0.08%	10.74%
XTrackers	3,131	5.24%	9.24%	-	0	**10.62%**	-	10.62%
Vanguard	2,525	5.21%	9.11%	-	0	**10.50%**	-	10.50%
Invesco	556	5.21%	9.05%	-	0	**10.44%**	-	10.44%
€ HY Corp Bonds	-	-	-	-	-	-	-	-
XTrackers	588	2.96%	10.37%	-	-	**10.78%**	-	10.78%
iShares	595	2.96%	10.39%	-	-	**10.80%**	0.47%	10.93%
€ Agg Bonds	6,020	7.65%	2.51%	-	-	**8.04%**	-	8.04%
SPDR	2,191	7.79%	2.70%	-	-	**8.25%**	-	8.25%
iShares	3,943	7.67%	2.57%	-	-	**8.09%**	0.37%	8.19%
US Treasuries	262	6.94%	-	25%	-	**27.57%**	-	27.57%
SPDR	238	6.48%	-	25%	-	**27.35%**	-	27.35%
Invesco	262	6.70%	-	25%	-	**27.45%**	-	27.45%
US Gov I-L Bonds	43	8.15%	-	25%		**28.16%**	-	28.16%
iShares	43	8.13%	-	25%	-	**28.15%**	4.04%	29.48%
Amundi	43	8.15%	-	25%	-	**28.16%**	0.25%	28.22%
Lyxor	43	8.19%	-	25%	-	**28.19%**	-	28.19%
SPDR	43	8.13%	-	25%	-	**28.15%**	-	28.15%
US Agg Bonds	12,007	6.16%	31.37%	25%	-	**46.00%**	-	46.00%
iShares	5,970	5.86%	29.67%	25%	-	**44.54%**	0.59%	44.79%
SPDR	1,424	5.96%	29.84%	25%	-	**44.70%**	-	44.70%
Global Agg Bonds	26,670	7.54%	15.12%	19.05%	1.20%	**29.42%**	-	29.42%
iShares	7,610	7.50%	14.74%	19.02%	1.27%	**29.13%**	0.06%	29.14%
SPDR	6,060	7.49%	14.79%	19.03%	1.28%	**29.16%**	-	29.16%
XTrackers	244	7.54%	15.12%	19.05%	1.20%	**29.42%**	2.90%	30.41%
UK Gov Bonds	-	-	-	-	-	-	-	-
Lyxor	55	12.35%	-	25%	-	**30.53%**	-	30.53%
iShares	58	12.35%	-	25%	-	**30.53%**	1.47%	30.95%

Like its competitors, iShares uses sampling to replicate many Fixed Income indices, especially if they have an important number of constituents. But iShares often implements sampling using an inhouse iShares money market fund and other iShares ETFs as well. The look through approach must also be applied on those funds. As the iShares money market fund invests in securities made out in USD, some iShares ETFs tracking EURO Fixed Income indices might display some SCR Currency at the margin.

3 Determination of the optimal replicating portfolio of ETFs for an insurance company

In this last chapter, we implement the Strategic Asset Allocation of an insurance company exclusively with ETFs, by applying to them the look through approach. All ETFs used come from our database, so we are able to build an optimal replicating portfolio which takes into account financial performance as well as SCR charge.

3.1 The insurance company's asset allocation and the ETFs relevant for its implementation

3.1.1 Recovering the Insurance Company's Strategic Asset Allocation

We choose randomly the holdings of one insurance company established in France in the ACPR dataset. We first exclude investments made for unit-linked contracts. Policyholders, not the insurance company, bear the market risk of such contracts. As a result, Solvency II does not require a capital charge for such investments. We then group remaining individual securities into one of the 8 following asset classes: **Euro Government Bonds, Euro Corporate Bonds, US Government Bonds, US Corporate Bonds, Euro Indexed Linked Bonds, US Indexed Linked Bonds, European Equities and Foreign Equities**. We have the market values invested into each asset class and thus their relative weights in the asset allocation of the insurer, as can be seen in Table 30, which are also simplied into rounded values, which are more convenient for the optimization.

Table 30: Observed and Simplified asset allocation of an insurance company established in France

Asset class	**Observed Weight**	**Simplified Weight**
Euro Government Bonds	79%	70%
Euro Corporate Bonds	15.5%	15%
US Government Bonds	1.5%	2%
US Corporate Bonds	3%	2%
Euro Government Indexed Linked Bonds	0.40%	5%
US Government Indexed Linked Bonds	0.10%	2%
European Equities	0.20%	2%
Foreign Equities	0.30%	2%

Source: ACPR, author's calculations

3.1.2 Selection of ETFs to represent the Strategic Asset Allocation

Next we select from our database all ETFs which could be used by the insurance company to implement its SAA. The main selection filter is that each index representing an asset class should be tracked by several ETFs. This will allow a straight comparison of ETFs' financial performance and SCR charge.

In our database, the 2,092 ETFs shares from the 10 European providers track 1,224 unique indices. 358 of those indices are tracked each time by at least 2 ETFs shares, for a total of 993 shares. But among those shares, there are:

- Shares from the same providers only differing by their distribution policy and no share from other providers.
- Pairs of shares with different distribution policy, i.e., one capitalization share and one distribution share only.

Such ETFs shares are of limited interest for the optimization program, so we exclude them. We end up with 496 ETFs shares tracking 126 indices. We then additionnaly remove ETFs shares where competition to track an index exists but where only synthetic ETFs compete. This is motivated by the objective of having as much diversity as possible in terms of replication strategy for each index. We end up with 421 ETFs shares tracking 95 indices.

We then exclude Equity sectors' ETFs shares, Equity styles' ETFs shares, Commodities ETFs shares and Fixed Income ETFs shares on specific maturity buckets, as they are neither essential nor relevant in an insurance company's strategic asset allocation.

We end up with 24 indices spread between 10 Fixed Income indices and 14 Equity indices. Among the 24 indices, some of them are quite similar (see infra). In addition, indices such as MSCI USA, Russell 2000 or Nasdaq 100 have been removed as there were already plenty of Equity indices. But they remain relevant candidates for an asset allocation and could have been used as well.

We select all ETFs tracking the 24 indices. For some of those ETFs only part of their price history will be relevant for the optimization:

- When ETFs changed their reference index over the last 5 years, we select only the timeperiod where they tracked the index which is of interest to us. Otherwise, Tracking Errors calculations would be biased. For instance, the physical replication ETF Amundi S&P 500 tracked the S&P 500 until October 2020, when it switched to the S&P 500 ESG Index. We exclude price data concerning this ETF after October 2020.
- When ETFs changed their dividend policy over the last 5 years, we select only the timeperiod with the relevant dividend policy, for the same reason as the previous point. For instance, Lyxor Euro Stoxx 50 switched from a distribution policy to a capitalization policy in January 2021. We exclude the price data concerning this ETF after January 2021.
- When ETFs switched their replication technique, we select only the timeperiod with the relevant replication technique. Over the period 2017-2021, XTrackers EUR Corporate

Bond and XTrackers EUR High Yield Corporate Bond were concerned by a switch from synthetic replication to physical replication. We keep only price data of those ETFs after they switched to physical replication.

We also make some exclusions in the candidate ETFs:

- We exclude ETFs which were incepted too recently, e.g., after 2020, such as iShares S&P 500 Swap, as they lack the minimum track record of 2 years.
- We also exclude ETFs with an AuM below 25 mln EUR.

We end up with 111 ETFs shares.

Fixed Income ETFs shares and their main characteristics are presented in Table 31.

Table 31: Fixed Income indices of the SAA and associated ETFs

Asset class	Index	curr-ency	provider	repli-cation	sec lending	payout policy
Euro Government Bond	BBG Barclays Euro Aggregate Treasury Bond TR	EUR	iShares SPDR Vanguard	sampled sampled sampled	Y N N	Dis Dis Dis
Euro Government Linkers	BBG Barclays Euro Govt I-L Bond all maturities TR	EUR	iShares XTrackers	sampled sampled	Y N	Acc Acc
Euro Corporate Bonds	BBG Barclays Euro Aggregate Corporate Bond TR	EUR	Invesco Vanguard iShares SPDR iShares Vanguard XTrackers	sampled sampled sampled sampled sampled sampled sampled	Y N Y N Y N Y	Dis Dis Dis Dis Acc Acc Acc
Euro High Yield Corporate Bonds	Markit iBoxx EURO Liquid High Yield	EUR	iShares XTrackers	sampled sampled	Y Y	Dis Dis
Euro Aggregate Bonds	BBG Barclays Euro Aggregate Index Value Unhedged	EUR	iShares SPDR	sampled sampled	Y N	Dis Dis
US Government Bonds	BBG Barclays US Treasury TR Unhedged	USD	Invesco SPDR	sampled sampled	Y N	Dis Dis
US Government Linkers	BBG Barclays US Government Inflation linked Bond All maturities TR	USD	iShares Lyxor Amundi	sampled full full	Y N Y	Acc Acc Acc
US Aggregate Bonds	BBG Barclays US Aggregate Bonds TR	USD	iShares SPDR	sampled sampled	Y N	Dis Dis
UK Government Bonds	FTSE Actuaries UK Conven--tionnal Gilts All Stocks	GBP	iShares Lyxor	sampled sampled	Y N	Dis Dis
Global Bonds	BBG Barclays Global Bond Aggregate Unhedged	USD	iShares SPDR XTrackers	sampled sampled swap	Y N N	Dis Dis Dis

Table 32 presents ETFs shares tracking European Equity indices, with their main characteristics.

Table 32: European Equity indices of the SAA and associated ETFs

Asset class	Index	currency	provider	replication	sec lending	payout policy
European Equities	Euro Stoxx 50	EUR	HSBC	full	Y	Dis
			Amundi	full	Y	Dis
			iShares	full	Y	Dis
			Lyxor	full	N	Dis
			Invesco	swap	N	Dis
			UBS	full	Y	Dis
			XTrackers	full	Y	Dis
			iShares	full	Y	Acc
			BNPPAM	full	N	Acc
			Lyxor	full	N	Acc
			Amundi	full	Y	Acc
			Invesco	swap	N	Acc
			XTrackers	full	Y	Acc
UK Equities	Footsie 100 Income	GBP	iShares	full	Y	Dis
			Vanguard	full	N	Dis
			XTrackers	full	Y	Dis
UK Equities	Footsie 250 TR	GBP	HSBC	full	Y	Dis
			iShares	full	Y	Dis
			XTrackers	full	Y	Dis
European Equities	MSCI Europe Net TR EURO	EUR	Amundi	swap	N	Acc
			Invesco	swap	N	Acc
			iShares	full	Y	Acc
			HSBC	full	Y	Dis
			iShares	full	Y	Dis
			UBS	full	Y	Dis
European Equities	Stoxx Europe 600 Net TR	EUR	Amundi	swap	N	Acc
			BNPPAM	swap	N	Acc
			Invesco	swap	N	Acc
			Lyxor	full	N	Acc
			XTrackers	sampled	Y	Acc
European Equities	MSCI Europe Net TR	EUR	SPDR	full	Y	Acc
			Amundi	full	Y	Acc
Euro area Equities	MSCI EMU Net TR	EUR	UBS	full	Y	Dis
			XTrackers	full	Y	Dis

Table 33 presents ETFs shares tracking international Equity indices, with their main characteristics.

Table 33: International Equity indices of the SAA and associated ETFs

Asset class	**Index**	**curr-ency**	**provider**	**repli-cation**	**sec lending**	**payout policy**
US Equities	S&P 500 Net TR	USD	Amundi	full	Y	Acc
			Amundi	swap	N	Acc
			BNPPAM	swap	N	Acc
			Invesco	swap	N	Acc
			iShares	full	Y	Acc
			UBS	swap	N	Acc
			Vanguard	full	N	Acc
			XTrackers	swap	N	Acc
			Lyxor	swap	N	Acc
			Invesco	swap	N	Dis
			BNPPAM	swap	N	Dis
			HSBC	full	N	Dis
			iShares	sampled	Y	Dis
			Lyxor	swap	N	Dis
			SPDR	full	N	Dis
			UBS	full	Y	Dis
			Vanguard	full	Y	Dis
Japanese Equities	MSCI Japan hedged to USD	USD	iShares	sampled	Y	Acc
			UBS	full	Y	Acc
Japanese Equities	MSCI Japan hedged to EUR	EUR	SPDR	sampled	N	Acc
			UBS	full	Y	Acc
Asian Equities	MSCI Pacific ex Japan	USD	HSBC	full	Y	Dis
			iShares	full	Y	Dis
			UBS	full	Y	Dis
Emerging Market Equities	MSCI Emerging Markets Net TR	USD	Amundi	full	Y	Acc
			Amundi	swap	N	Acc
			Invesco	swap	N	Acc
			iShares	full	Y	Acc
			Lyxor	swap	N	Acc
			SPDR	sampled	N	Acc
			UBS	sampled	Y	Acc
			UBS	swap	N	Acc
			XTrackers	sampled	Y	Acc
			XTrackers	swap	N	Acc
			UBS	sampled	Y	Dis
			iShares	full	Y	Dis
			Amundi	full	Y	Dis
			HSBC	sampled	Y	Dis
Global Equities	MSCI World Daily TR	USD	HSBC	sampled	Y	Dis
			iShares	full	Y	Dis
			UBS	sampled	Y	Dis
			SPDR	full	N	Acc
			UBS	full	Y	Acc
			Lyxor	sampled	N	Acc
			XTrackers	sampled	Y	Acc
			XTrackers	swap	Y	Acc
			Invesco	swap	N	Acc
			iShares	full	Y	Acc
Global Equities	MSCI World Net Return EUR	EUR	Amundi	full	Y	Acc
			Amundi	swap	N	Acc

3.1.3 ETFs' financial performances

We now calculate TDs and TEs of the 111 ETFs. The calculation of the performance and the relative performance of dividend-paying ETFs shares (D-shares) has some specificity. On dividend payment dates, the NAV of D-shares is reduced by the amount of dividend paid, like for the price of a bond at coupon payment dates. This puts a drag on their excess return. As a result, Tracking Differences of D-shares are biased downward, and Tracking Errors are biased upward. There are many solutions to remove this bias. For instance, one could "reinvest" the dividend into new shares of the ETF on dividend payment dates. The solution we propose is to compute the NAV return on dividend payment dates by adding the dividend to the NAV. The excess return we calculate is then not biased anymore, and consistent series of TDs and TEs can be obtained as a result.

Coming to the calculation of Tracking Errors, there are numerous calculation methodologies available. Bioy et al (2013) highlight that "It is important to realise that the calculation of tracking error can result in different values depending on a variety of factors which include but are not limited to: i. The frequency of observations, i.e. whether daily, weekly or monthly data is used; ii. The day chosen as the starting point for the calculation when weekly data is used, i.e. whether weekly returns are calculated from Friday to Friday, Monday to Monday, etc., or also whether weekly average data is used iii. The time period, i.e. whether tracking error is calculated over one, three or five years, or longer. As of today, ETF providers are at liberty to adjust any of these parameters when calculating and publishing tracking error, unless a standard methodology is imposed by the regulator of the country where the fund is domiciled. For example in France, the AMF requires the disclosure of an ex-post tracking error based on the standard deviation of weekly return differences".

Following AMF's requirements, we compute Tracking Differences and Tracking Errors using weekly excess returns of the NAV versus the index. Tracking Difference and Tracking Error are thus annualized by multiplying them by respectively 52 and $\sqrt{52}$:

$$TD = 52 \times \frac{1}{T} \times \sum_{i=1}^{T} ER_i^w. \qquad TE = \sqrt{52 \times \frac{1}{T} \times \sum_{i=1}^{T} (ER_i^w - TD)^2}. \tag{30}$$

with T the number of weeks

Our approach is consistent with the observations made by Bioy et al (2013) on the need to have a measure in adequacy with the investment horizon: "Suffice it to say that there is no one best way of measuring tracking error. The best metric ultimately depends on each investor's profile and objective. Certain investors may prefer one frequency of data over another depending on their investment horizon and the length of a fund's history. Specifically, looking at daily data over a short time period might be more appropriate for someone who trades these funds frequently, while weekly or monthly data over a few years' horizon might be more relevant for a long term investor, provided that the number of data points is sufficient to make the calculation statistically meaningful."

This is why in the below examples, we use a weekly frequency over a timeperiod of 5 years (2017-2021). ETFs prices could have been used instead of the NAV, but we do not. First, the look through approach concerns the assets of the fund represented by the NAV. Second, the price on exchange is usually biased compared to the NAV.

We present in Table 34 below TDs and TEs of the 111 ETFs shares by distribution policy, by asset class and by replication technique:

Table 34: TD and TE by ETFs' distribution policy, asset class and replication technique

ETFs by	Distribution policy		Asset Class		Replication technique		All ETFs
	Capitalization	Distribution	Fixed Income	Equity	Physical	Synthetic	
# of ETFs	56	55	28	83	86	25	111
ann. TD (%)	0.003%	-0.025%	-0.156%	0.04%	-0.035%	0.074%	-0.011%
ann. TE (%)	0.10%	0.12%	0.08%	0.12%	0.12%	0.071%	0.11%

In our sample, ETFs Capitalization shares display a larger TD than Distribution shares, Equity ETFs shares display a larger TD than Fixed Income ETFs and Synthetic ETFs shares display a larger TD than physical ETFs. This is consistent with the findings of Hurlin et al (2019).

Tracked indices are made out in different currencies, such as EUR, USD, GBP. All ETFs and indices' returns are expressed into one of those currencies. All metrics presented in the above Tables are based on the performance of ETFs and indices in their original currencies.

3.1.4 Spreading all relevant indices into different Strategic Asset Allocations

Some indices are tracked by both Capitalization shares and Distribution shares, such that we have actually 31 groups of ETFs tracking a specific index with a specific distribution policy at our disposal. We cannot use those 31 groups to represent a unique asset allocation, as it is unrealistic to envisage an asset allocation represented by 31 asset classes. In addition, among the 24 indices, some can be quite similar in nature, such as the Footsie 100 or the Footsie 250 for UK Equities. This is why we propose six different representations of the insurer's asset allocation which differ from each other by at least one index. In their nature and risk characteristics those six representations are equivalent. Spreading the 31 groups of ETFs into six declinations of the asset allocation first allows to exploit extensively available information. In addition, it is more grounded economically to spread indices similar in nature into different asset allocations. It would not make sense indeed to combine almost redundant indices in the same allocation as the same exposure would be represented many times. The six representations of the strategic asset allocation are displayed in Tables 35 and 36. US Corporates Bonds are replaced by "other equities" in the asset allocation, as we have plenty of such indices and no Corporate Bonds indices. The distribution policy of ETFs used to track each index are put in brackets.

Table 35: Representations of the insurance company's asset allocation

Weight	Representation #1	Representation #2	Representation #3
70%	Euro Govt Bonds (D)	Euro Govt Bonds (D)	Euro Agg Bonds (D)
15%	Euro Corp Bonds (D)	Euro HY Corp Bond (D)	Euro Agg Bonds (D)
2%	US Govt Bonds (D)	US Agg Bonds (D)	UK Govt Bonds (D)
5%	Euro Linkers (A)	Euro Linkers (A)	Euro Agg Bonds (D)
2%	US Linkers (A)	US Agg Bonds (D)	US linkers (A)
2%	Euro Stoxx 50 (A)	MSCI Europe Net TR EURO (D)	Stoxx Europe 600 (A)
2%	FTSE 100 (D)	FTSE 250 (D)	S&P 500 (A)
2%	MSCI Japan Hedged to EUR (A)	MSCI Japan Hedged to USD (C)	MSCI Pacific ex Japan (D)

Table 36: Representations of the insurance company's asset allocation (continued)

Weight	Representation #4	Representation #5	Representation #6
70%	Global Bonds (D)	Global Bonds (D)	Global Bonds (D)
15%	Global Bonds (D)	Global Bonds (D)	Global Bonds (D)
2%	Global Bonds (D)	Global Bonds (D)	Global Bonds (D)
5%	Global Bonds (D)	Global Bonds (D)	Global Bonds (D)
2%	Global Bonds (D)	Global Bonds (D)	Global Bonds (D)
2%	MSCI Europe Net TR (A)	Euro Stoxx 50 (D)	MSCI EMU Net TR (D)
2%	MSCI World (A)	MSCI World Daily (D)	S&P 500 (D)
2%	MSCI EM (A)	MSCI EM (D)	MSCI World (C)

3.2 ETFs financial performance net of Excess SCR illustrated

Following our selection methodology, for each asset class of the insurance company's asset allocation, we have many ETFs in competition. We illustrate some elements that the insurance company should consider to select an ETF on a given asset class, by looking successively at three indices and some of the ETFs tracking each index from our database: Stoxx Europe 600 NR, MSCI Europe Net TR index and MSCI Europe Net TR EURO Index. We only use Capitalization shares for that purpose, as their performance is easier to interpret visually. SCR values are averaged over the period 2017-2021 to be consistent with the timeperiod over which ETFs' financial performance are calculated. The insurance company should take both elements into consideration for ETFs' selection.

Table 37 presents results the SCR subcomponents and total SCR some ETFs tracking the Stoxx Europe 600 NR Index (Bloomberg ticker SXXR) on February 17th 2021:

Table 37: ETFs and Index SCRs compared for SXXR, February 17th 2021

Provider	**# components**	**SCR Equity**	**SCR Currency**	**SCR Market**	**SCR Counterparty**	**SCR Total**
SXXR	600	39%	11.96%	43.56%	0	43.56%
Lyxor MEUD	602	39%	12.74%	43.95%	0	43.95%
BNPPAM ETZ	47	39%	11.96%	43.56%	0.94%	43.81%
XTrackers XSX6	605	39%	11.98%	43.57%	0.29%	43.64%

Table 38 adjusts ETFs' TDs with Excess SCRs obtained with figures from Table 37.

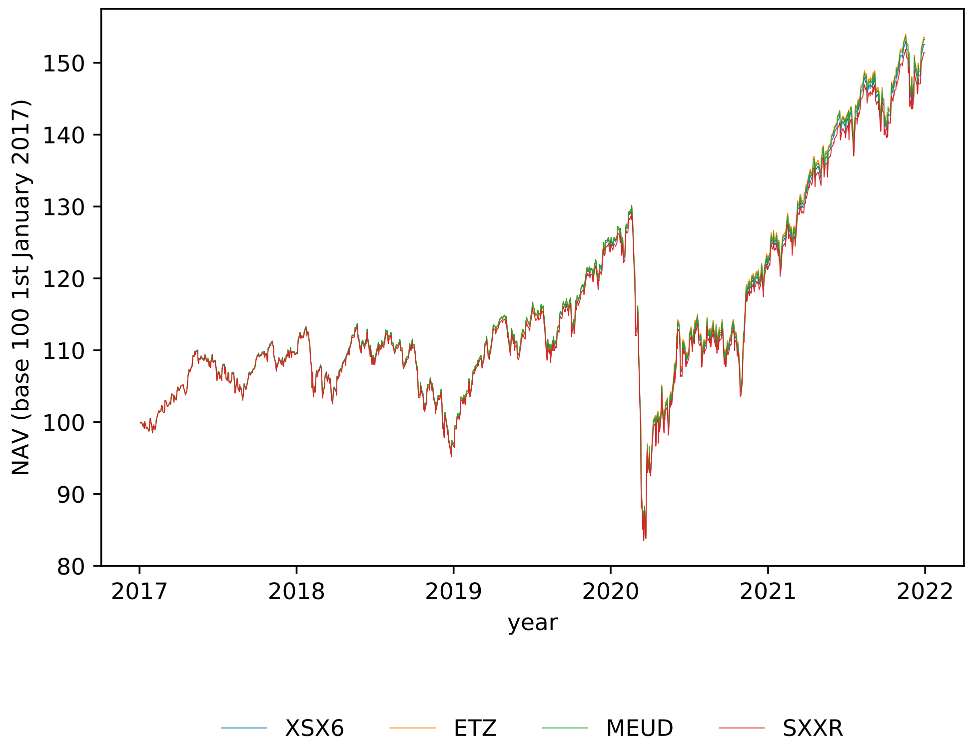
Table 38: ETFs tracking performances and capital charges compared to SXXR, February 17th 2021

Index	**Provider**	**replication**	**security lending**	**TD**	**TE**	SCR_{XS}	**TD net of** SCR_{XS}
SXXR	Lyxor MEUD	full	N	**0.25%**	0.09%	0.39%	**-0.14%**
	BNPPAM ETZ	swap	N	**0.29%**	0.08%	0.25%	**0.04%**
	XTrackers XSX6	full	Y	**0.16%**	0.09%	0.08%	**0.08%**

BNPPAM ETF tracking Stoxx Europe 600 NR delivers the highest TD among its peers, but this is not the case anymore when adjusting TD for Excess SCR and XSX6 is then the ETF with the highest TD net of Excess SCR.

Figure 11 represents performances of ETFs tracking the Stoxx Europe 600 NR Index since January 2017 at a daily frequency.

Figure 11: Compared performances (C shares)



Source: Bloomberg

Table 39 presents results the SCR subcomponents and total SCR some ETFs tracking the MSCI Europe Net TR Index (Bloomberg ticker M7EU) on February 17th 2021:

Table 39: ETF and Index SCRs compared for M7EU Index, February 17th 2021

Provider	**# components**	**SCR FX**	**SCR Equity**	**SCR Market**	**SCR Counterparty**	**SCR Total**
M7EU						43.65%
SPDR ERO	436	12.15%	39%	43.65%	0	43.65%
Amundi CEU2	430	12.40%	39%	43.78%	6.74%	45.93%

Table 40 adjusts ETFs' TDs with Excess SCRs obtained with figures from Table 39.

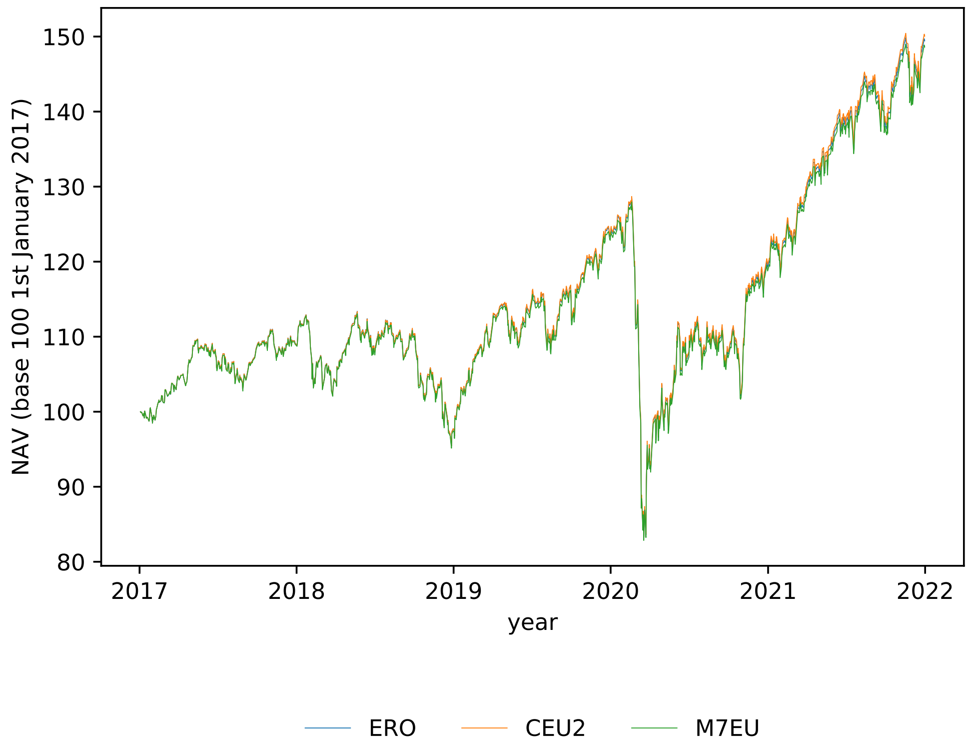
Table 40: ETFs tracking performances and capital charges compared to M7EU, February 17th 2021

Index	**Provider**	**replication**	**security lending**	**TD**	**TE**	SCR_{XS}	**TD net of** SCR_{XS}
M7EU	SPDR ERO	full	N	**0.11%**	0.09%	0	**0.11%**
	Amundi CEU2	full	Y	**0.19%**	0.10%	2.28%	**-2.09%**

Amundi CEU2 offers a significantly better TD than its competitor SPDR ERO, but this is not the case anymore if it is adjusted for Excess SCR.

Figure 12 represents performances of ETFs tracking the MSCI Europe Net TR Index since January 2017 at a daily frequency.

Figure 12: Compared performances (C shares)



Source: Bloomberg

Table 41 presents results the SCR subcomponents and total SCR some ETFs tracking the MSCI Europe Net TR EURO Index (Bloomberg ticker MSDEE15N) on February 17th 2021:

Table 41: ETF and Index SCRs compared for MSDEE15N, February 17th 2021

Provider	**# components**	**SCR FX**	**SCR Equity**	**SCR Market**	**SCR Counterparty**	**SCR Total**
MSDEE15N	432	11.10%	39%	43.12%	-	43.12%
iShares SMEA	433	12.43%	39%	43.79%	0.84%	44.01%
Amundi CEU	267	11.10%	39%	43.12%	0	43.12%
Invesco SMSEUR	200	11.10%	39%	43.12%	0.61%	43.28%

Table 42 adjusts ETFs' TDs with Excess SCRs obtained with figures from Table 41:

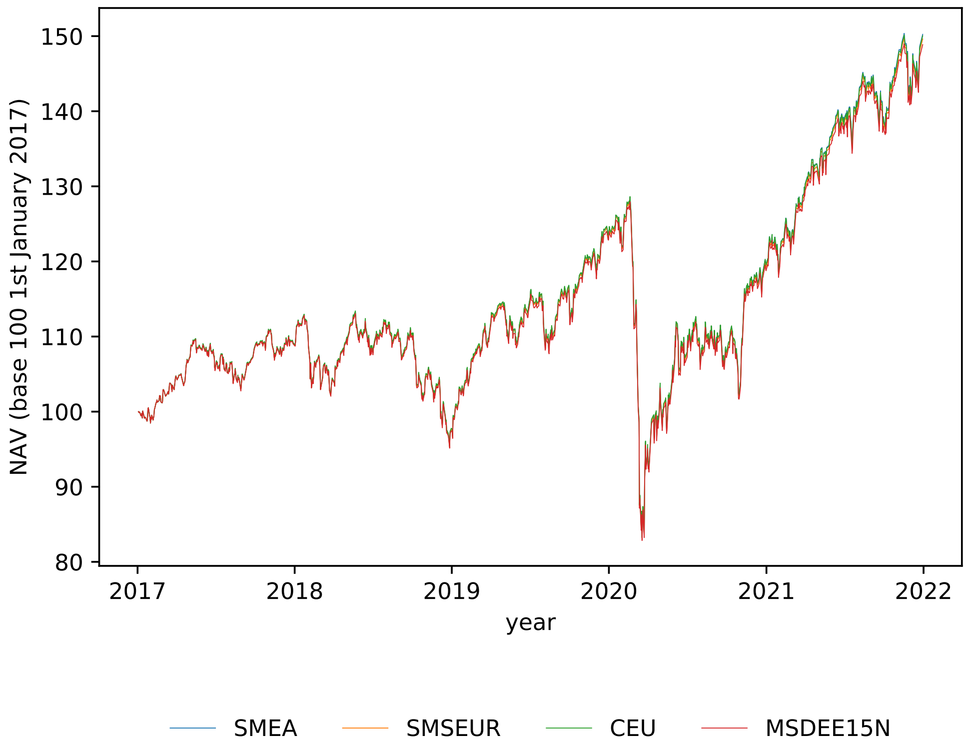
iShares SMEA delivers the highest TD among its peers, but this is not the case anymore if it is adjusted for Excess SCR, and Amundi CEU delivers the highest TD net of Excess SCR.

Table 42: ETFs tracking performances and capital charges compared to MSDEE15N, February 17th 2021

Index	**Provider**	**replication**	**security lending**	**TD**	**TE**	SCR_{XS}	**TD net of** SCR_{XS}
MSDEE15N	Amundi CEU	swap	N	**0.16%**	0.05%	0%	**0.16%**
	Invesco SMSEUR	swap	N	**0.10%**	0.07%	0.16%	**-0.06%**
	iShares SMEA	full	Y	**0.19%**	0.08%	0.89%	**-0.70%**

Figure 13 represents performances of ETFs tracking the MSCI Europe Net TR EURO Index since January 2017 at a daily frequency.

Figure 13: Compared performances (C shares)



Source: Bloomberg

3.3 A model for the insurance company's optimal portfolio of replicating ETFs

We have introduced in the previous section a "standalone" approach of ETFs' selection for a given index, by comparing ETFs' TDs net of Excess SCR, ignoring their TEs so far. In this section we propose a "portfolio" model of ETFs selection for the entire asset allocation of the insurance company.

Roll's seminal paper (1992) develops a model for building an optimal portfolio when it is managed in reference to an index. The index-linked portfolio manager aims at minimizing the variance of the difference in returns between the portfolio and the index, subject to the desired threshold on portfolio Tracking Difference (and a budget constraint):

$$\min_{w} \ (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\Sigma}(\mathbf{w}-\mathbf{w}^I) \ \text{ s.t } \begin{cases} (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\mu} & = G. \\ (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\iota} & = 0. \end{cases}$$

$\boldsymbol{\Sigma}$ is the $(n \times n)$ covariance matrix of the returns of assets in the portfolio

$\boldsymbol{\mu}$ is the $(n \times 1)$ vector of mean returns on assets in the portfolio

$\mathbf{w}$ is the $(n \times 1)$ vector of weights on assets in the portfolio

$\mathbf{w}^I$ is the $(n \times 1)$ vector of weights on assets in the index

$\boldsymbol{\iota}$ is a $(n \times 1)$ unitary vector

G is a threshold on the portfolio mean excess return

There are alternative reformulations of this optimization program, such as maximizing the Tracking Difference subject to a Tracking Error budget

$$\max_{w} \ (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\mu} \ \text{ s.t } \begin{cases} (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\Sigma}(\mathbf{w}-\mathbf{w}^I) & = k^2. \\ (\mathbf{w}-\mathbf{w}^I)'\boldsymbol{\iota} & = 0. \end{cases}$$

k is a threshold on the index fund Tracking Error

To sum up, to select an optimal index-tracking portfolio, a portfolio manager can maximize the portfolio average TD, subject to a tracking error budget and a constraint on the weights of assets in the portfolio.

We adapt this model to the problem of selecting an optimal tracking portfolio of ETFs for an insurance company's asset allocation, by transposing TD and TE at the asset allocation level:

- **The Tracking Error of the weighted average return on the portfolio of ETFs with respect to the return on the SAA** should be minimized. Tracking Error is not considered at the portfolio level anymore, but at the allocation level.
- **The Tracking Difference on the portfolio of ETFs** should be maximized.
  But when transposing the index fund model to the insurance company, one should also take into account the capital charge required by Solvency II. Actually, index SCRs should not be taken into account. They have implicitly already been factored in to determine the SAA of the insurance company. The deployment of the SAA into ETFs will only

generate a capital charge in the form of the Excess SCR that we have introduced. Thus only Excess SCR should be taken into account as it is the only regulatory capital charge not yet taken into account in the SAA to replicate.

To conclude, in our framework, the insurer **maximizes the Tracking Difference on the ETFs portfolio net of its Excess SCR, subject to a constraint on the Tracking Error of the excess return of the ETFs portfolio**. But maximization is not implemented anymore over weights on the different ETFs. We impose the weight on each ETF to be equal to the weight of the tracked index in the allocation.

We stress that **the model presented is not a model to determine the strategic asset allocation of an insurance company, but a model to implement its SAA** and this is the reason why we do not take into account the liabilities of the insurance company here. We take the asset allocation of the insurance company for granted and only care about deploying funds into the desired asset classes by using ETFs.

3.4 Formalization of the insurance company's optimization program

For the sake of clarity, we first express the insurance company's optimization program without SCR requirement. We enrich the program with Excess SCR afterwards.

3.4.1 Optimization without the SCR capital charge

- There are 6 Strategic Asset Allocations (SAAs) to replicate. For $1 \leq j \leq 6$, the j^{th} SAA, is made of N_j asset classes. Its characteristics are given by:

$$\mathbf{w}^j = \begin{pmatrix} w_1^j \\ w_2^j \\ \vdots \\ w_{N_j}^j \end{pmatrix} \quad \mathbf{r}^j = \begin{pmatrix} r_1^j \\ r_2^j \\ \vdots \\ r_{N_j}^j \end{pmatrix} \quad \boldsymbol{\mu}^j = \begin{pmatrix} \mu_1^j \\ \mu_2^j \\ \vdots \\ \mu_{N_j}^j \end{pmatrix}$$

$\mathbf{w}^j$: vector of the relative weights (%) of asset classes in j^{th} AA

$\mathbf{r}^j$: vector of assets classes' returns in j^{th} AA. Asset classes returns are actually returns of indices representing each asset class.

$\boldsymbol{\mu}^j$: vector of assets classes' expected returns in j^{th} AA

- The return on the j^{th} AA is equal to the weighted average of asset classes' returns:

$$r_{AA}^j = \sum_{i=1}^{N_j} w_i \times r_i^j = \boldsymbol{w^{j\prime}}\mathbf{r}^j. \tag{31}$$

- Thus the average return on the j^{th} AA is equal to:

$$\mu_{AA}^{j} = \boldsymbol{w^{j\prime}} \boldsymbol{\mu}^{j}. \tag{32}$$

- There are N_j asset classes in the j^{th} SAA. For asset class i, $(1 \leq i \leq N_j)$, there are n_i ETFs in competition with the following characteristics:

$$\mathbf{r}_{ETF,i}^{j} = \begin{pmatrix} r_{ETF,i}^{j,1} \\ r_{ETF,i}^{j,2} \\ \vdots \\ r_{ETF,i}^{j,n_i} \end{pmatrix} \qquad \boldsymbol{\mu}_{ETF,i}^{j} = \begin{pmatrix} \mu_{ETF,i}^{j,1} \\ \mu_{ETF,i}^{j,2} \\ \vdots \\ \mu_{ETF,i}^{j,n_i} \end{pmatrix}$$

$\mathbf{r}_{ETF,i}^{j}$: vector of the returns of the n_i ETFs tracking index i in j^{th} AA.
$\boldsymbol{\mu}_{ETF,i}^{j}$: vector of the expected returns of the n_i ETFs tracking index i in j^{th} AA.

- There are 31 groups of ETFs representing 31 asset classes. For $1 \leq i \leq 31$ and $1 \leq k \leq n_i$, the excess return of ETF k tracking index i writes:

$$ER_i^k = r_{ETF,i}^{k} - r_i. \tag{33}$$

$r_{ETF,i}^{k}$: return on ETF k tracking index i.
r_i: return on index i.

The TD of ETF k tracking index i writes:

$$TD_i^k = \mu_{ETF,i}^{k} - \mu_i. \tag{34}$$

$\mu_{ETF,i}^{k}$: expected return on ETF k tracking index i.
μ_i: expected return on index i.

- Then, for the j SAAs, we build all possible combinations of ETFs, obtained by trying all combinations of ETFs in every asset class. The number of combinations of unique replicating portfolios by asset allocation is given below:

  - 5184 for asset allocation #1
  - 432 for asset allocation #2
  - 1620 for asset allocation #3
  - 420 for asset allocation #4

– 189 for asset allocation #5

– 96 for asset allocation #6

- We denote by $r^{j,c}_{ETF,i}$ the ETF return from the vector $\mathbf{r}^{j}_{ETF,i}$ which is present in the c^{th} combination. $ER^{j,c}_i$ and $TD^{j,c}_i$ are respectively the excess return and the TD of this ETF. The Excess Return of the c^{th} combination for the j^{th} AA then writes:

$$ER^{j,c} = \sum_{i=1}^{N_j} w^j_i \times ER^{j,c}_i = \sum_{i=1}^{N_j} w^j_i \times (r^{j,c}_{ETF,i} - r^j_i). \tag{35}$$

- In the c^{th} combination of the j^{th} AA, the covariance matrix of ETFs' Excess Returns with respect to their indices is given by:

$$\mathbf{\Sigma}^{j,c}_{ER} = \begin{pmatrix} (\sigma^{j,c}_1)^2 & \sigma^{j,c}_{1,2} & \cdots & \sigma^{j,c}_{1,N_j} \\ \sigma^{j,c}_{2,1} & (\sigma^{j,c}_2)^2 & \cdots & \sigma^{j,c}_{2,N_j} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma^{j,c}_{N_j,1} & \sigma^{j,c}_{N_j,2} & \cdots & (\sigma^{j,c}_{N_j})^2 \end{pmatrix}$$

With $\sigma^{j,c}_{u,v}$ the covariance between excess return of ETF tracking asset class u and the excess return of ETF tracking asset class v in the c^{th} combination of ETFs in the j^{th} AA.

- Without any prudential constraints, the optimal replicating portfolio of ETFs is obtained by solving the following program for the j^{th} AA:

$$\max_c \; TD^{j,c} \text{ s.t } \begin{cases} TE^{j,c} & = k. \\ \mathbf{w}^{ETF} & = \mathbf{w}^j. \end{cases}$$

With k the Tracking Error budget.

Which rewrites:

$$\max_c \; \mathbf{w}^{ETF'} \boldsymbol{TD^{j,c}} \text{ s.t } \begin{cases} \mathbf{w}^{ETF'} \mathbf{\Sigma}^{j,c}_{ER} \mathbf{w}^{ETF} & = k^2. \\ \mathbf{w}^{ETF} & = \mathbf{w}^j. \end{cases}$$

TDs and TEs are based on ETFs and indices' performance in their original currencies. It is not relevant to proceed to a global conversion in EURO to find the optimal portfolio.

What matters is that all ETFs tracking a given index are made out in the same currency, which is by construction the case. Of course, the overall TD and TE of a given replicating portfolio must be understood as a proxy of the real TD and TE of the portfolio, as it is a combination of TDs and TEs expressed in different currencies. As we are only interested in the nature of the optimal portfolio, not its financial performance, such conversions are not necessary.

There is no closed-form solution to this program, only numerical solutions. Solving the program does not consist in finding optimal weights as in classical optimal portfolios programs. Here, weights on each ETF are fixed.

Replicating portfolios' Tracking Differences and Tracking Errors are estimated using excess Returns computed at a weekly frequency using market data on the period 2017-2021, or less if the ETF was incepted after 2017. When ETFs in a given combination do not cover the same timeperiod, we use all available data per ETF to estimate its TD anyway, so TDs might be estimated over different timeperiods. Conversely, to compute covariances between ETFs in any given combination, only the timeperiod where all ETFs were alive simultaneously is used.

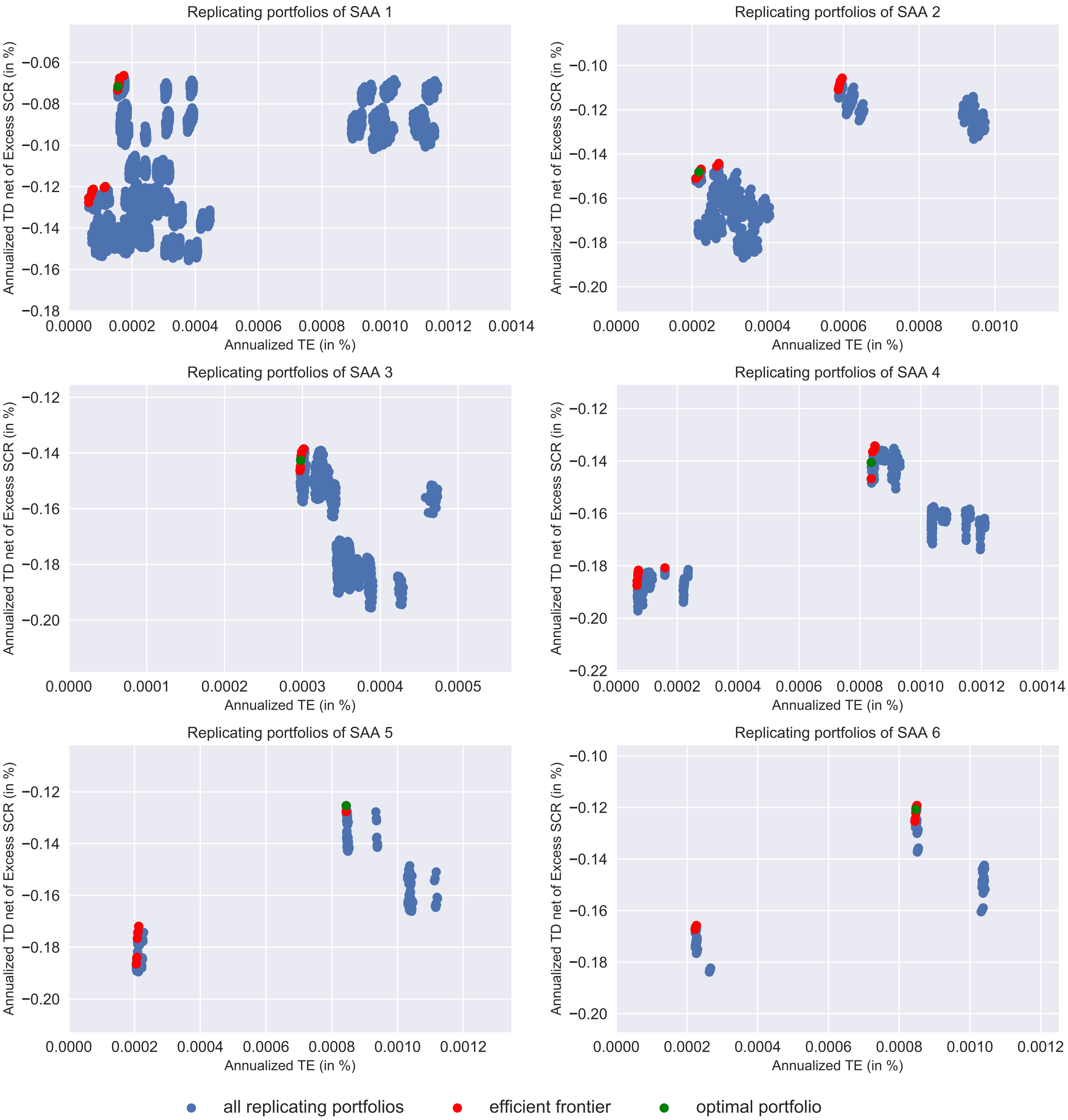
To find the efficient frontier, we first compute TDs and TEs for all replicating portfolios of a given SAA. We then rank replicating portfolios by increasing level of TE. We then calculate the variation in TD for any two consecutive replicating portfolios, and remove all portfolios whose TD is lower than the previous portfolio's TD, i.e. portfolios whose variation in TD is negative. For each of those portfolios, there exists a portfolio with a higher TD and a lower TE, so they are not efficient. We repeat that process as long as there are negative variations in TD for consecutive replicating portfolios. **The Efficient Frontier of replicating portfolios is the ouput of that process**.

Then, to determine the most efficient portfolio on the efficient frontier we need a Tracking Error budget. Without such information, it is still possible to determine the most efficient portfolio of ETFs:

- We can compute the slope of the efficient frontier between any consecutive replicating portfolios. The portfolio situated at the righthandside of the segment with the highest slope is the most efficient portfolio. Indeed, it provides with the highest incremental TD for an increase in 1 unit of TE
- We can also count, for each index tracked, ETFs with the highest number of occurrences on the efficient frontier.

We plot all replicating portfolios in the TD/TE space in the series of plots in Figure 14 below.

Figure 14: All combinations of replicating portfolios and their efficient frontiers



3.4.2 Optimization including the SCR capital charge

Let us now enrich the optimization program of the insurer by adding the weighted average Excess SCR entailed by each portfolio of ETFs:

$$\max_{c} \; TD^{j,c} - SCR^{j,c}_{excess} \;\; \text{s.t} \;\; \begin{cases} TE^{j,c} & = k. \\ \mathbf{w}^{ETF} & = \mathbf{w}^{j}. \end{cases}$$

Which rewrites approximately:

$$\max_{c} \; \mathbf{w}^{ETF\prime}(\boldsymbol{TD^{j,c}} - \boldsymbol{SCR}^{j,c}_{excess}) \;\; \text{s.t} \;\; \begin{cases} \mathbf{w}^{ETF\prime}\boldsymbol{\Sigma}^{j,c}_{ER}\mathbf{w}^{ETF} & = k^2. \\ \mathbf{w}^{ETF} & = \mathbf{w}^{j}. \end{cases}$$

with $\boldsymbol{SCR}^{j,c}_{excess}$ the vector of average Excess SCR for each tracked index of the c^{th} combination of ETFs in the j^{th} AA. Again, TDs net of Excess SCR are estimated using historical data on the period 2017-2021.

The optimization program we solve is an approximation of the effective optimization program. We assume indeed that $SCR^{j,c}_{excess} = \mathbf{w}^{ETF\prime}\boldsymbol{SCR}^{j,c}_{excess}$, but the SCR of a portfolio of ETFs is not a weighted average of SCRs of each ETF, and this is also the case for Excess SCRs.

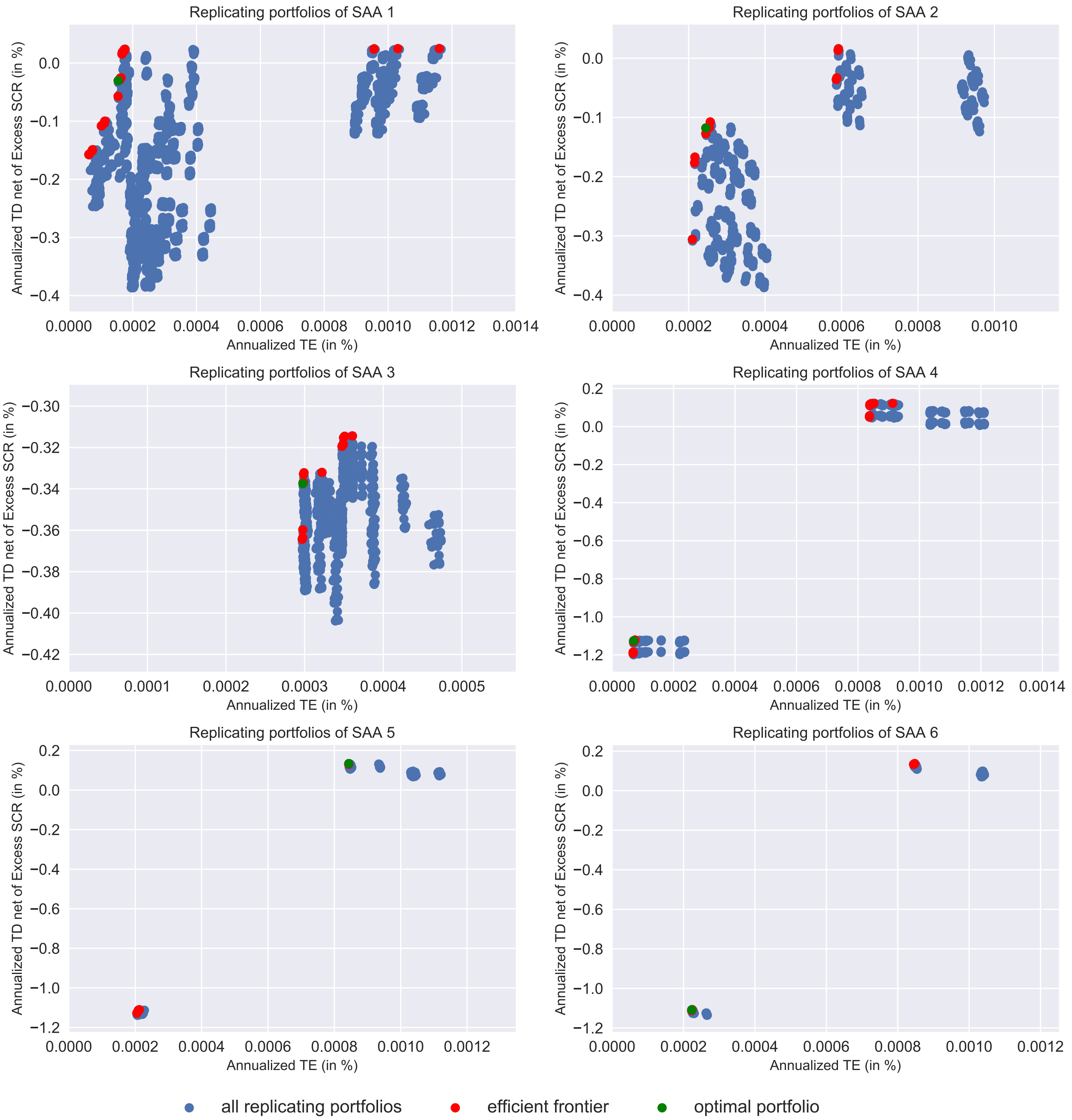
With the introduction of the excess SCR, we expect some changes in the optimal replicating portfolio, as there might be a trade off between excess SCR and financial performance:

- If an ETF fully replicates an index and does not lend securities, it might come up with a lower incremental SCR (as it does not embed Counterparty Risk SCR), but at the expense of a lower Tracking Difference.
- Conversely, an ETF using a Securities Financing Transaction technique is likely to have a higher incremental SCR due to counterparty risk, but it is also expected to have a higher TD than a full replication ETF. SFTs are indeed often used to increase the return of the ETF against its index.
- A sampled ETF is also likely to display an improved Tracking Difference compared to a full replication ETF, as it purchases only a subset of the tracked index and minimizes transaction costs. But it might come up with a less diversified portfolio and thus a higher SCR Concentration.

To solve this new optimization program, we compute for all replicating portfolios TDs net of Excess SCR and TEs. Using the same method as for the first optimization, we obtain the efficient frontier of replicating portfolios and compute the slope between any two consecutive portfolios to determine the optimal replicating portfolio of ETFs.

We get updated efficient frontiers of replicating portfolios in the TD/TE space, which are plotted in the series of graphs in Figure 15 below.

Figure 15: All combinations of replicating portfolios and their efficient frontiers with Excess SCR



3.5 Optimization results and conclusions

In Tables 43 to 48 we present optimal replicating portfolios for each asset allocation. ETFs from optimal replicating portfolios which do not take Excess SCR into account are in blue and ETFs from optimal replicating portfolios which take Excess SCR into account are in red.

Often, ETFs having recourse to SFTs are optimal when Excess SCR is not taken into account, but are replaced by ETFs with a more simple replication technique when excess SCR is taken into account. This means that the financial benefit of the SFT disappears when the SCR reflecting that additional risk is taken into account. There are however a few situations where the opposite result shows up. This might be due to the influence of correlation. ETFs using different replication techniques might have lower levels of correlation than ETFs using similar replication techniques. When an ETF using no SFT becomes optimal in a replicating portfolio taking Excess SCR into account, it is sometimes the case that an ETF using SFTs becomes optimal in the same replicating portfolio on another part of the allocation.

Table 43: Optimal portfolio for Asset Allocation #1

Index	Provider	Div Policy	Rep method	Sec lending	TD	TE	Net TD	w/o SCR	with SCR
Bloomberg	Amundi	A	Full	Y	-0.07	0.10	-0.13	Amundi	
US Govt	iShares	A	Sampled	Y	-0.15	0.02	-1.47		
I-L Bonds	Lyxor	A	Full	N	-0.09	0.01	-0.12		Lyxor
Bloomberg €	iShares	A	Sampled	Y	-0.23	0.01	-1.14	iShares	iShares
Govt I-L Bonds	Xtrackers	A	Sampled	N	-0.20	0.22	-0.15		
Bloomberg €	iShares	D	Sampled	Y	-0.13	0.03	-0.34		
Aggregate	SPDR	D	Sampled	N	-0.15	0.02	-0.14		
Treasury TR	Vanguard	D	Sampled	N	-0.07	0.13	0.04	Vanguard	Vanguard
Bloomberg	iShares	D	Sampled	Y	-0.16	0.05	-0.29		
€ Aggregate	Vanguard	D	Sampled	N	-0.07	0.11	0.02	Vanguard	Vanguard
Corporate	Invesco	D	Sampled	N	-0.22	0.22	-0.05		
Bonds	SPDR	D	Sampled	N	-0.18	0.05	-0.39		
Bloomberg	Invesco	D	Sampled	Y	-0.03	0.03	0.09	Invesco	
US Treasury TR	SPDR	D	Sampled	N	-0.14	0.02	0.08		SPDR
MSCI Japan €	UBS	A	Full	Y	-0.27	0.13	-0.43	UBS	UBS
Hedged NTR	SPDR	A	Sampled	N	-0.36	0.35	-0.36		
	iShares	A	Full	Y	0.50	0.17	0.44		
	Invesco	A	Swap	N	0.38	0.17	0.20		
Euro Stoxx	Amundi	A	Full	Y	0.44	0.17	0.36		
50 NR	BNPPAM	A	Full	N	0.36	0.18	0.36	BNPPAM	BNPPAM
	Lyxor	A	Full	N	0.57	0.19	0.57		
	Xtrackers	A	Full	Y	0.50	0.17	0.48		
FTSE	Xtrackers	D	Full	Y	-0.14	0.10	-0.14		
100	iShares	D	Full	Y	-0.02	0.09	-0.11	iShares	iShares
NTR	Vanguard	D	Full	Y	-0.07	0.05	-0.07		

Table 44: Optimal portfolio for Asset Allocation #2

Index	**Provider**	**Div Policy**	**Rep method**	**Sec lending**	**TD**	**TE**	**Net TD**	**w/o SCR**	**with SCR**
BBG € Govt	iShares	A	Sampled	Y	-0.23	0.01	-1.14	iShares	
I-L Bonds	Xtrackers	A	Sampled	N	-0.20	0.22	-0.15		XTrackers
FTSE UK	Xtrackers	D	Full	N	-0.28	0.06	-0.29	XTrackers	XTrackers
	iShares	D	Full	Y	-0.43	0.08	-0.77		
Series 250 TR	HSBC	D	Full	Y	-0.48	0.08	-0.48		
Markit iBoxx	iShares	D	Sampled	Y	-0.24	0.18	-0.37		
€ Liquid HY	Xtrackers	D	Sampled	Y	-0.19	0.10	-0.19	XTrackers	XTrackers
Bloomberg US	iShares	D	Sampled	Y	-0.29	0.09	0.92	iShares	iShares
Aggregate TR	SPDR	D	Sampled	N	-0.23	0.22	0.02		
Bloomberg	iShares	D	Sampled	Y	-0.13	0.03	-0.34	iShares	
€ Aggregate	SPDR	D	Sampled	N	-0.15	0.02	-0.14		SPDR
Treasury TR	Vanguard	D	Sampled	N	-0.07	0.13	0.04		
MSCI Japan $	UBS	A	Full	Y	-0.32	0.10	-0.49	UBS	
Hedged NTR	iShares	A	Sampled	Y	-0.73	0.12	-0.99		iShares
MSCI Europe	UBS	D	Full	Y	0.13	0.08	0.05		
	iShares	D	Full	Y	-0.01	0.45	-0.24		
NTR €	HSBC	D	Full	Y	0.19	0.09	0.19	HSBC	HSBC

Table 45: Optimal portfolio for Asset Allocation #3

Index	**Provider**	**Div Policy**	**Rep method**	**Sec lending**	**TD**	**TE**	**Net TD**	**w/o SCR**	**with SCR**
Bloomberg	Amundi	A	Full	Y	-0.07	0.10	-0.13		Amundi
US Govt	iShares	A	Sampled	Y	-0.15	0.02	-1.47	iShares	
I-L Bonds	Lyxor	A	Full	N	-0.09	0.01	-0.12		
FTSE Actuaries	iShares	D	Sampled	Y	-0.10	0.04	-0.52		
UK Conv. Gilts	Lyxor	D	Sampled	N	-0.09	0.02	-0.09	Lyxor	Lyxor
Bloomberg €	iShares	D	Sampled	Y	-0.20	0.04	-0.35		
Aggregate TR	SPDR	D	Sampled	N	-0.16	0.03	-0.37	SPDR	SPDR
MSCI Pacific	iShares	D	Full	Y	-0.51	0.07	-0.86		
	UBS	D	Full	Y	-0.24	0.08	-0.33	UBS	UBS
ex Japan NTR	HSBC	D	Full	Y	-0.31	0.08	-0.31		
	iShares	A	Full	Y	0.24	0.02	0.20		
	Vanguard	A	Full	Y	0.22	0.03	0.22		
	UBS	A	Swap	N	0.18	0.02	0.18		
	Invesco	A	Swap	N	0.45	0.04	0.37		
S&P 500 NTR	Amundi	A	Swap	N	0.45	0.03	0.45	Amundi	Amundi
	BNPPAM	A	Swap	N	0.53	0.05	0.26		
	Lyxor	A	Swap	N	0.47	0.02	0.47		
	Xtrackers	A	Swap	N	0.52	0.02	0.23		
	Amundi	A	Full	N	-0.09	0.22	-0.55		
	Xtrackers	A	Sampled	Y	0.16	0.09	0.07		
Stoxx Europe	Invesco	A	Swap	N	0.06	0.09	0.02		Invesco
600 NR	Amundi	A	Swap	N	0.06	0.05	0.06		
	BNPPAM	A	Swap	N	0.29	0.08	0.04		
	Lyxor	A	Full	N	0.25	0.09	0.25	Lyxor	

Table 46: Optimal portfolio for Asset Allocation #4

Index	Provider	Div Policy	Rep method	Sec lending	TD	TE	Net TD	w/o SCR	with SCR
Bloomberg	SPDR	D	Sampled	N	-0.17	0.11	0.09		
Global	iShares	D	Sampled	Y	-0.14	0.09	0.14	iShares	
Aggregate TR	Xtrackers	D	Swap	N	-0.19	0.02	-1.19		XTrackers
MSCI Europe	SPDR	A	Full	Y	0.11	0.09	0.08		SPDR
Net TR	Amundi	A	Full	Y	0.19	0.10	-2.94	Amundi	
	UBS	A	Sampled	Y	-0.11	0.06	-0.23		
	iShares	A	Full	Y	0.07	0.06	-0.10		
	Xtrackers	A	Sampled	Y	0.07	0.04	0.07		
MSCI World	Lyxor	A	Sampled	N	0.01	0.19	0.01	Lyxor	
NTR $	SPDR	A	Full	N	0.07	0.08	0.07		SPDR
	Xtrackers	A	Swap	Y	0.06	0.03	-0.16		
	Invesco	A	Swap	N	0.12	0.03	0.04		
	iShares	A	Full	Y	-0.46	0.11	-0.61		
	UBS	A	Swap	N	-0.45	0.03	-0.45		UBS
	UBS	A	Sampled	Y	-0.32	0.34	-0.35		
	Invesco	A	Swap	N	-0.53	0.02	-0.77		
MSCI Emerging	Xtrackers	A	Sampled	Y	-0.24	0.09	-0.24		
Markets NTR	SPDR	A	Sampled	N	-0.27	0.32	-0.27		
	Xtrackers	A	Swap	N	-0.54	0.03	-0.80		
	Lyxor	A	Swap	N	-0.75	0.04	-0.75		
	Amundi	A	Swap	N	-0.44	0.07	-0.44	Amundi	
	Amundi	A	Full	Y	-0.33	0.15	-0.64		

Table 47: Optimal portfolio for Asset Allocation #5

Index	Provider	Div Policy	Rep method	Sec lending	TD	TE	Net TD	w/o SCR	with SCR
Bloomberg	SPDR	D	Sampled	N	-0.17	0.11	0.09		
Global	iShares	D	Sampled	Y	-0.14	0.09	0.14	iShares	iShares
Aggregate TR	Xtrackers	D	Swap	N	-0.19	0.02	-1.19		
MSCI World	UBS	D	Full	Y	-0.19	0.05	-0.26		
	iShares	D	Full	Y	-0.22	0.06	-0.46		
NTR $	HSBC	D	Sampled	Y	0.30	0.17	0.30	HSBC	HSBC
MSCI Emerging	UBS	D	Sampled	Y	-0.33	0.21	-0.36	UBS	UBS
	HSBC	D	Sampled	Y	-0.45	0.26	-0.45		
Markets NTR	iShares	D	Sampled	Y	-0.50	0.12	-0.66		
	Xtrackers	D	Full	Y	0.48	0.23	0.46		
	UBS	D	Full	Y	0.44	0.18	0.35		
	Invesco	D	Swap	N	0.37	0.17	0.19		
EuroStoxx 50 NR	Amundi	D	Full	Y	0.43	0.17	0.35		
	Lyxor	D	Full	N	0.43	0.17	0.43		
	HSBC	D	Full	Y	0.55	0.17	0.55	HSBC	HSBC
	iShares	D	Full	Y	0.35	0.33	0.27		

Table 48: Optimal portfolio for Asset Allocation #6

Index	Provider	Div Policy	Rep method	Sec lending	TD	TE	Net TD	w/o SCR	with SCR
Bloomberg	SPDR	D	Sampled	N	-0.17	0.11	0.09		
Global	iShares	D	Sampled	Y	-0.14	0.09	0.14	iShares	
Aggregate TR	Xtrackers	D	Swap	N	-0.19	0.02	-1.19		XTrackers
MSCI EMU	Xtrackers	D	Full	Y	0.36	0.15	0.28		
NTR €	UBS	D	Full	Y	0.32	0.13	0.24	UBS	UBS
MSCI World	Amundi	A	Full	Y	-0.05	0.11	-0.63		
NTR €	Amundi	A	Swap	N	-0.09	0.01	-0.09	Amundi	Amundi
	UBS	D	Full	Y	0.17	0.03	0.11		
	SPDR	D	Full	N	0.05	0.22	0.05		
	iShares	D	Full	Y	0.23	0.04	0.12		
S&P 500 NTR	Invesco	D	Swap	N	-0.31	0.58	-0.39		
	BNPPAM	D	Swap	N	0.52	0.04	0.25	BNPPAM	
	HSBC	D	Full	N	0.29	0.13	0.29		
	Lyxor	D	Swap	N	0.45	0.02	0.45		Lyxor
	Vanguard	D	Full	Y	0.22	0.04	0.22		

We conclude that ETFs most suited to insurance companies are in their majority physical ETFs which are not involved in securities lending (or lend only a tiny portion of their asset base), or synthetic ETFs which have a daily swap reset policy. This means that ETFs which do not use SFTs, or which use SFTs but manage their counterparty risks with daily margin calls, are ETFs most suited to an insurance company when it implements the look through approach.

We can think of many avenues to extend our work on this topic. First, some refinements could be envisaged in the calculation of the SCR Counterparty for securities lending transactions, as has been already pointed out earlier. The frequency of the calculation of SCR Market and SCR Counterparty could also be increased by asking ETFs' providers for higher frequency reportings. In addition, various methods could be used to improve the estimate of the covariance matrix of excess returns. At last, a more intensive usage of the ACPR dataset could also be envisaged. It could be used to examine whether the enforcement of Solvency II has modified the demand of French insurance companies for ETFs. Some replication strategies might now be favored by insurance companies. Fixed-Income ETFs might also be looked after as they are not considered as Equities anymore. We could test such ideas using the ACPR dataset which covers a timeperiod starting well before the enforcement of Solvency II, on a large group of insurance companies.

But we can also underline an important limit to the look through approach when it comes to ETFs. For sure, it is consistent with the spirit of Article 84 of the Delegated Regulation to apply the look through approach to ETFs' NAVs and not to their prices, as the NAV is the reflection of the ETFs' direct exposures. However, as we already underlined, ETFs are sold on exchange at a price generally different from their NAV. In situations of market stress, this difference is exacerbated, as the price of ETFs can trade well below their NAV, where the

NAV is already reflecting the stressed value of ETFs' assets. The risk of a price discrepancy with the NAV is material to an insurance company, as such discounts versus the NAV reflect the actual value at which ETFs can be sold during such episodes. It could be relevant to think of an additional capital buffer to take such a risk into account. This capital buffer would be added to the SCR obtained when applying the look through approach.

Conclusion

This memoir started from the observation that the application of Article 84 of Solvency II's Delegated Regulation was poorly or not implemented at all by insurance companies for the calculation of the SCR on their Exchange-Traded Funds, and with the expectation that the SCR to apply to such products could be higher than the ones of their tracked indices. ETFs employ a variety of lending and replication techniques which generate some form of counterparty risk indeed.

To test our idea we developed a database of ETFs' Securities Financing Transactions (i.e. securities lending and swap transactions) of the ten largest European ETFs providers representing 93% of the European ETFs market, by taking advantage of the enforcement of SFTR regulation in 2016 in Europe. This database covers transactions since 2016 onwards, at a semi annual frequency. To our knowledge this is the first time a database gathering all relevant information on the counterparty risk of ETFs has been elaborated.

We also conducted a rigorous interpretation and application of Article 214 of the Delegated Regulation which edicts the rules required to consider a collateral arrangement as valid. Such arrangements constitute a major element in the management of counterparty risks. Our current interpretation of the text considers some collateral arrangements as not valid.

ETFs' set ups themselves had to be analyzed in light of the Standard Formula. The SF guidance was indeed originally not designed to cover all the complex dimensions found in the asset management space and its application on ETFs' replication set ups required some interpretation.

We then computed the SCR Counterparty of the majority of ETFs lending securities and many ETFs using the synthetic set up in our database. We then developed a new risk metric, the "Excess SCR", which is the difference between the SCR of an ETF and the SCR on its tracked index. This metric is inspired from the ETF excess return and is somewhat its "counterpart" in the risk domain.

We also proposed many axes of refinements for the calculation of the SCR Counterparty on securities lending transactions, as the current approach is not very granular.

At last, we introduced a model for the implementation of an asset allocation for an insurance company which considers deployings funds into ETFs, instead of holding asset classes directly. This model is inspired by traditional index tracking portfolio models and adapted to our objective. First, the model is fitted to an asset allocation , i.e. to a weighted average of indices, and not to one single index. Second, the model is enriched by internalizing the Excess

SCR, i.e. the additional capital charge stemming from ETFs' deviation in SCR from their index due to excess Counterparty and Market Risks.

The main conclusion from this model is that the financial benefits of ETFs using SFTs to enhance their returns can disappears when Excess SCR is internalized in the portfolio model, such that they are replaced in the optimal portfolio. As this Excess SCR mainly results from the usage of SFTs, this suggests that ETFs most suited to insurance companies are ETFs in physical replication which do not rely on SFTs, or synthetic ETFs which submit their swap counterparties to daily margin calls.

References

[1] ACPR (2015), "Notice 'Solvabilité II', Calcul du SCR en formule standard," *présentation ACPR.*

[2] Banque de France Stat Info (2015), "Placements financiers des sociétés d'assurance - France - 1e trimestre 2015," *Banque de France.*

[3] Banque de France Stat Info (2021), "Placements financiers des sociétés d'assurance - France - 3e trimestre 2021," *Banque de France.*

[4] Bioy, H. and Rose, G. (2012), "Securities Lendings in Physical Replication ETFs: a review of providers practices," *Morningstar ETF Research.*

[5] Bioy, H., Davidson, L., Johnson, B. and Kellett A. (2013), "On The Right Track: Measuring Tracking Efficiency in ETFs," *Morningstar ETF Research.*

[6] Boyde E. (2021), "ETF securities lending almost doubles in four years" *Financial Times, ETF Hub.*

[7] Briand, J., Dard, A., Cambou, A. and Dussutour JJ. (2016), "Prêts et emprunts de titres: traitement sous Solvabilité II," *note interne ACPR.*

[8] Club Ampère (2015), "Solvency II Reporting for ETFs. From index replication to derivatives look-through, a consistent approach based on the TPT Template," *Club Ampère.*

[9] Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC of the European Parliament and of the Council on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II) (2014).

[10] ESMA (2014), "Guidelines on ETFs and Other UCITS Issues," *ESMA*, ESMA/2014/937EN.

[11] Domange, M. and Trotin G. (2019), "Parcours de formation Solvabilité II, SCR 'Risque de marché et de contrepartie'," *présentation ACPR restreinte.*

[12] The European Parliament and the Council (2009), "Directive 2009/138/EC on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II)."

[13] The European Parliament and the Council (2015), (EU) 2015/2365 on transparency of securities financing transactions and of reuse and amending Regulation (EU) n° 648/2012."

[14] The European Parliament and the Council (2009), "Directive 2009/65/EC on the coordination of laws, regulations and administrative provisions relating to undertakings for collective investment in transferable securities (UCITS)."

[15] The European Parliament and the Council (2012), "Regulation (EU) n° 648/2012 on OTC derivatives, central counterparties and trade repositories."

[16] Gallet, S., Slama, S., Guimiot, F. and Roero C. (2018), "Une part Croissante d'OPC dans les placements financiers des assureurs établis en France en 2017," *Bulletin de la Banque de France*, 220/4.

[17] Grill, M., Lambert, C., Marquardt, P., Watfe G. and Weistroffer C. (2018), "Counterparty and liquidity risks in exchange-traded funds," *European Central Bank Financial Stability Review*, pp. 154-168

[18] Hurlin, C., Iseli, G., Perignon, C. and Yeung S. (2019), "The Counterparty Risk Exposure of ETFs Investors," *Journal of Banking & Finance*, Vol. 102, pp. 215-230.

[19] Natixis Asset Management Fixed-Income (2016), "Solvency II Capital Requirements for Debt Instruments, Impact of Solvency II on the Debt Markets."

[20] PWC Assurance (2014), "Solvency 2, de nouveaux leviers pour l'allocation d'actifs. Pourquoi votre allocation d'actifs va profondément changer dans les prochaines années," *PWC*.

[21] PWC Resolutions (2016), "How regulations and taxes are shaping the future of ETFs," *PWC*.

[22] Roll R. (1992), "A Mean-Variance Analysis of Tracking Error," *Journal of Portfolio Management*, Vol. 18, pp. 13-22.

[23] Schwartz D. (2014), "Will Securities Lending Indemnification Be Regulated Into Oblivion?" *Center for The Study of Financial Market Evolution*.

[24] Vanguard Investments Research and Commentary (2020), "Fixed income myths, part 2: 'Bond indexing is simple'," *Vanguard Investments*.