MODEL IMPLEMENTATION

MR: Market Risk

AV: Additional Value Adjustment Models

XXXX: **Concentrated positions**

TI: Model Implementation

SP: Spain

LOCAL

TABLE OF CONTENTS

1 INTRODUCTION

This document contains the model implementation for SCIB Boadilla unit for the Additional Value Adjustments (AVA) referred to the concepts of Concentration related to the concentration of the portfolio positions (Concentrated Positions).

The model and tool have been defined according to existing Concentrated Positions and available data in the European market. However, the tools might be used in other circumstances analyzing the particularities of the local market, through developing an intermediate tool (or a manual pathway) to process different sources of information in order to calibrate the bid-ask or uncertainty values finally used by the AVA calculator.

The methodology implemented in the calculator may be consulted in the Model Theory document.

In brief, the tool determines the positions which would require of over 10 days to close the position after the given inputs. These will be the concentrated positions. Once these have been determined, a prudent exit price is estimated, and an adjustment is calculated based on the current mid-price and the prudent price. For calculating the prudent price, several inputs are required, among others an average traded volume and a volatility per ISIN. Additionally, since not every product is expected to have an input, a proxy has been defined as to infer any missing data.

Currently, the main sources of input data of the mentioned Concentrated Positions are Markit, Bloomberg and Asset Control (AC). If a different source or different format should be used, the implementation should be adapted, or a new tool should be developed to preprocess the information from that source obtaining directly the data to be used in the calculations.

This document detail the following list of local aspects of the model:

- Description of local portfolios and scope.
- Details of the inputs currently used, how they are processed, and a brief description of the tools currently used to obtain all the inputs[1].
- Configuration of the model.
- Details about the local implementation (functional point of view).
- Consistency analysis for certain assumptions.
- Technical implementation.
- Local monitoring and control.

[1] By the time this document is being written, there is a tactical implementation coded in Python that can be run in the user PC where the inputs are expected to be located in a particular directory in Excel or CSV format. When the model will be fully integrated in corporate systems, the process to provide the inputs to the model will be fully automatized and described in the corresponding documentation by IT

2 SCOPE AND PORTFOLIO DESCRIPTION

This section collects information about the scope of Spain Concentrated Positions books and a brief summary of the type of products and underlyings present in the portfolios.

2.1 Scope

The scope for Concentrated Positions is given by the following books (names according to the Data Lake field "book"):

Desks Included
xVA
CREDIT BS Madrid
MM CREDIT IG USA
STM
COLATERAL SECURITY LENDING
ACPM Macro Hedge
FX_SPOT
eFX
OPCIONES_FX
FX_FWD
MIGRACION INTERNAS
UNIDAD MINORISTA RF
PRIMARY BOOK MADRID
LARGO_RATES
GOVIES BS Madrid
GOVIES STFGO
DERIVADOS INFLACION
EQ DERIVATIVES
VOLA_RATES
MINORISTA CORPORATE AND COMMERCIAL
BANKING BS MADR
CREDIT NY OFFSHORE
FX NY OFFSHORE
MARKET MAKING ARGENTINA OFFSHORE
MARKET MAKING SANTILLANA
MARKET MAKING LIBRO BRASIL EUROPA NO
VOLATILIDAD
ACPM SOTUS
GOVIES BS Madrid
ACPM Negociación
ACPM Inversión
ACPM ESPAÑA
Gestión de Balance
Emisora Santander España S.A.

Table 1: Books included in the scope for Concentrated Positions AVA as of 31/03/2021

Actually, the query to the data lake used for Concentrated Positions during the development is the following, where the complementary filters are there essentially for performance reasons.

```
Select status, mtype, source_system, book, portfolio, instrument, security_code,
security_currency,     pl_ccy,     nominal_unit,     maturity,     maturity_real,
maturity_bond,  price,  coupon,  evaluation_price,  amortization_type,  internal,
lot_size, buy_sell, capital_factor, Trade_date,  sum(nominal) as nominal_suma,
sum(cast(nominal as DOUBLE)*cast(capital_factor as DOUBLE)) as suma_nominal_cf,
sum(quantity)        as        quantity_suma,        sum(cast(quantity        as
DOUBLE)*cast(capital_factor as DOUBLE))

AS  suma_quantity_cf  from  cd_gcb_financial_formalised_contracts.trade_details
where data_date_part="2021-03-31" and asofdate="2021-03-31" and pnl_type ="EOD"
and  country_code  =  "ES"  and  (status=  "LIVE"  or  status=  "MKT_OP"  )   and
```

```
mfamily="IRD" and mgroup="BOND" and source_system not in ("Mx3EU_P5_HOM_01", "Mx3EQ_HOM_01", "Mx3EU_P5_HOM_02", "Mx3EU_HOM_01", "Mx3EQ_PAR_01")

GROUP BY status, mtype, source_system, book, portfolio, instrument, security_code, security_currency, pl_ccy, nominal_unit, maturity, maturity_real, maturity_bond, price, coupon, evaluation_price, amortization_type, internal, lot_size, buy_sell, capital_factor, Trade_date
```

Note that the information in the data lake is at trade level, but that level is not relevant for AVA and can be removed. The query preserves mandatory axis as:

- **security_code**: ISIN code of the different instruments to which an adjustment must be calculated
- **book**: in order to be able to distribute the adjustments between the different books.
- **source_system**: Data source from where the data is fed

For convenience some other fields are extracted in case any special treatment is necessary at any of those levels or for informative purposes.

2.2 Portfolio Description

In order to develop the present methodology and scope, valuation exposures from the Supra Datalake has been considered, which correspond to Bonds and ABS nominal. It should be noted that this is a specific example for fixed income products, but the analysis could also cover other positions.

Regarding both Bonds and ABS, the main valuation inputs are the market access percentage, the average traded volume and the volatility of the underlying price. The rest of the parameters are portfolio data –such as notional or AC price–, which should be provided, and no calculus would be required. In this sense, the 10 ISINs with more position are the following:

ISIN	Absolute notional % over the total
ES0L02110085	5.96%
ES0L02203047	5.14%
ES0L02201140	4.82%
IT0005437303	2.92%
ES0L02111125	2.90%
ES0L02202114	2.85%
IT0005434961	2.14%
IT0005422487	1.36%
IT0005412348	1.34%
ES00000128O1	1.30%

Table 2: Top ISINs per notional at 31/03/2021

3 INPUTS: DESCRIPTION, COLLECTING AND PROCESSING

This section complements the input section contained in the Model Theory documentation ([4]), including all the details, sources, the process to be obtained and the treatment of the raw data, before building the calculator inputs. With respect to the treatment the section describes the necessary filters for registers with empty field or outliers and the necessary transformations to covert the information of prices of instruments into bid-ask or uncertainty relative to the specific risk factor.

The following paragraphs describe details and evidence from the analysis of model inputs used for the calculation of the concentration. The average traded volume and the volatility have been particularly defined for fixed income securities, being a case of the total scope of Concentrated Positions. However, it should be noted that this is a specific example for fixed income products, but the analysis could also cover other positions.

Additionally, it is to highlight how the model data provisioning -average traded volume, volatility and static data- and its calculations belongs to the IPV team. This will ensure that the input data and the calculations in between are controlled, and therefore that these will be provided correctly.

Therefore, the model inputs involved for Concentrated Positions are the following:

3.1 Positions

All fair-valued assets, such as equity or fixed income included in the banking book for which a change in accounting valuation has a partial or zero impact on CET1 capital, are in scope for assessing whether a concentrated position is held. It will only make the assessment on executed transactions (whenever they are given in repo or not), temporary assets acquisitions will not be considered.

Since Grupo Santander operates in completely liquid and deep derivative markets, these products fall outside the concentrated positions environment. However, each unit is responsible for the identification of derivative operating in limited markets (operational limitations) and for including it, if necessary, in the concentrated position analysis.

For example, for Boadilla SCIB portfolio, the Bond portfolios and the ABS portfolios classified at Fair Value through Profit and Loss (FVPL) and Held to Collect and Sale (HC&S), according to GER[2], are considered in the AVA concentration adjustment. As a result, 2869 bonds and 324 ABS are considered in the aforementioned adjustment[3].

Nominal amounts (in the issuance currency) are obtained from the Trade Details located in SUPRA Datalake and fed from Murex. The nominal amounts are fed at trade level. Additionally, in some cases, specific accounting adjustments must be applied to the notional available in SUPRA (e.g., instruments with specific amortization rates). The level of aggregation of those nominals is defined by entity, ISIN and portfolio, including all positions without discriminating through accounting category.

Obtaining the nominal amounts from the Supra Datalake has the advantage to collect updated information as it is registered in the FO systems, without transformations or filters. Nevertheless,

---

[2] A back-office master repository that includes all relevant information for a portfolio.

[3] In TradeDetails there are instruments with Nominal equal to zero that are not being taking in consideration.

at this moment, the nominal information is certified and adjusted in MIS+. This means that if a material issue is identified in MIS+, it should be also translated into the Datalake in order to calculate correct AVAs. In the strategic implementation that will be carried out by IT teams, the positions might be extracted from other official repository fed with the data lake information, as it is expected to be the case of MARS, without any relevant consequence once that repository has all the necessary controls and checks to be used for official reporting.

3.2 Average daily traded volume

One of the market inputs used in the model is the average daily traded volume per ISIN, which determines the capacity of the market to absorb positions.

i. Data capture

The average daily traded volume for bonds is based on the information collected in the last 12 Markit monthly files[4], provided by IPV. These files contain, among other information, the notional traded per ISIN in outright transactions and repo in a particular month. The fields used are:

- *STL Sum Nom Amt USD*
- *TRP Sum Nom Amt USD*

Markit details that the volume data is sourced from TRACE and Euroclear. As Euroclear is considered as it is one of the greatest clearing houses in the world, the information is considered to be representative for the modelling purposes for the Madrid unit.

Below, there is an analysis of the Santander portfolio with information at ISIN level of the coverage obtained (as at the date of development of the methodology):

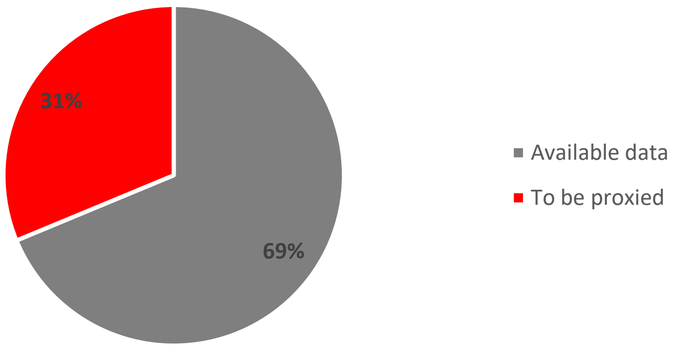

Figure 1: Bank bond position with available data for average traded volume as of 31/03/2021

The portfolio data with no information on market volumes in Markit will have to be proxied or provided to the tool through a different file. In this sense, traded volume from the Brazilian Central Bank for Brazilian sovereign bonds, as well as evidence from FO for short term Spanish debt from MTS are incorporated as model inputs.

For ABS, the information available is from Bloomberg RUNs and MSGs which are downloaded from a private dashboard by the IPV team. Some of these quotes are executable up to the notional

[4] The information registered in Markit is scarce. For this reason, the last 12 Markit monthly files are considered. This timespan allows to gather enough information about the volume of the concentrated positions and avoids using excessively outdated information.

posted at ISIN level. For these instruments, due to the OTC nature of the market executable quotes are considered instead of the volume of executed trades. The same as for CoC and MPU in the ABS FVA/AVA model methodology, a monthly download of trades is considered.

The reason for not considering the same window as for bonds is that, due to the OTC nature of the ABS market, the number of observations is reduced. Therefore, considering a year data could entail generating slanted proxies, or inferring false traded volumes due to having incomplete data through time. By considering a monthly data, the most recent market movements will be considered, and these will reflect best the market's ability to buy or sell a position.

The following graph presents the percentage of coverage with that source in terms of notional:

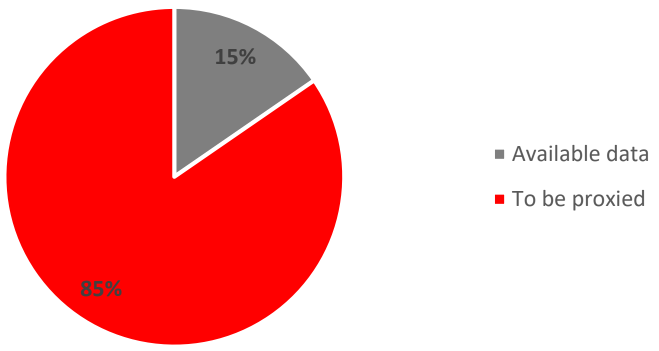

Figure 2: Bank ABS position with available data for average traded volume as of 31/03/2021

In principle, the coverage in ABS is much more reduced than for bonds, due to the OTC nature of the market that often works on demand. Particularly. the market is the buy side and most entities want to hold the ABS for investment purposes. In this regard, it is fair to build a proxy with the volumes of executable quotes executable available and to apply this proxy to the references with no data available. Thus, the appetite of the market to those type of bonds can be inferred from those with data available.

ii. Data building

The data building procedure will be executed by the IPV team and will be provided in EUR currency for bonds as of model development date.

The outright transactions and repo total notional are added up for each monthly file and will be assumed to be the total traded notional of the month. Once this value has been obtained, it is divided by the number of business days of the month (set at 22 for simplicity) for those instruments which have at least 4 observations of data through the Markit files. The result per ISIN will be considered its daily average traded notional.

$$average\ traded\ volume_{ISIN}^{Month\ i} = \frac{\sum_{ISIN \in i-th\ Markit\ file} Outright\ notional_{ISIN} + Repo\ notional_{ISIN}}{22}$$

Where the $i - th\ Markit\ file$ refers to the Markit file for month i and $Outright\ notional_{ISIN}$ and $Repo\ notional_{ISIN}$ to the total notional traded in outright transactions and repo respectively, for the particular $ISIN$.

This process is repeated for each file, generating a *daily average traded volume* per month, averaging after the months for which data files are provided.

$$average\ traded\ volume_{ISIN}^{bond} = \frac{\sum_{i \in \{Months\}} average\ traded\ volume_{ISIN}^{Month\ i}}{\#\{ISIN \in Markit\ Files\}}$$

Where $average\ traded\ volume_{ISIN}^{Month\ i}$ refers to the average daily traded volume calculated in step above.

For ISINs with no data available, a proxy based on the volumes observed for similar instruments will be used. For this purpose, buckets of instruments sharing common characteristics are defined.

As for bonds, the data treatment procedure for ABS will be performed by the IPV team, but these volumes should be converted to EUR currency.

$$Volume\ ABS\ (€) = \frac{Volume\ ABS}{FX\ rate}$$

The starting point is monthly data download of executable quotes. The executable actual notional per ISIN is aggregated on a daily basis, when there is an executable amount. The daily volume is aggregated at ISIN level for the entire monthly observation period and then divided by the number of days in the month where an executable quote has been offered by a contributor.

$$average\ traded\ volume_{ISIN}^{ABS} = \frac{\sum_{trade \in RUNS} Notional_{ISIN}(trade)}{\#\{date : \exists BidPrice_{ISIN}^{date}\}}$$

Where $Notional_{ISIN}(trade)$ denotes the traded notional for a given ISIN on the trade $trade$, and $BidPrice_{ISIN}^{date}$ represents the bid price for a given ISIN on date $date$[5].

The resulting value per ISIN will be considered as the average daily traded volume for each loaded ABS in the file.

When the use of proxies is required, a proxy market volume will be generated by classifying the ABS with executable volumes per bucket according to their characteristics. The percentile 50 of the volumes for the ABS which have an executable quote will be used as proxy at bucket level.

For those references without market quotes, the construction of proxy prices is required in order to calculate AVA adjustments. The proxies applied for Concentrated Positions are discussed in the Model Theory Documentation *[3]*.

3.3 Volatility

One additional input required for the execution of the model is a series of historical prices in order to generate the volatility.

---

[5] Unlike Bonds, the denominator in the ABS Average Trading Volume equation is the number of days with a bid price. The ABS market works under demand, so if demanded, an instrument is traded. Thus, it is considered that, in those days of the month in which the ABS does not appear in the price report, it has not been demanded although there is available volume. In order to not unfairly penalize the ABS Average Traded Volume, the denominator only considers the days with bid price reported. Hence, it is considered that, in those days with no volume reported, the available volume is the average of the days which has volume reported.

i. Data capture

The data capture consists of retrieving from AC historical series of prices per ISIN with a time-depth of one year. See below the availability of data (at the reference date used for the model development) for the calculation of the historical volatility for Bonds and ABS, as an example:

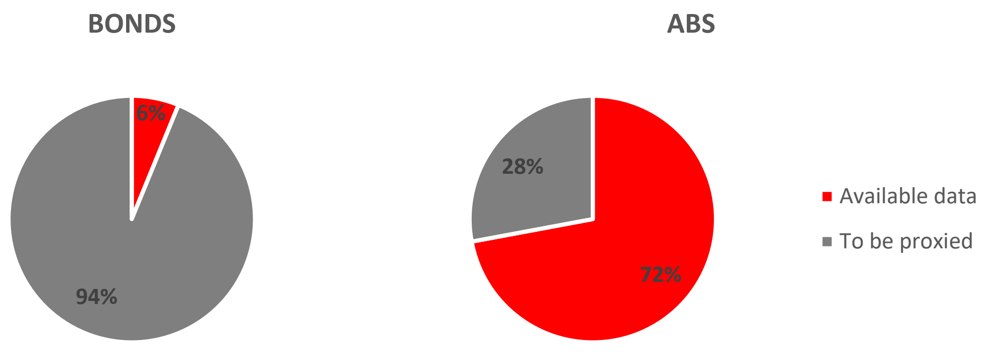

Figure 3: Percentage of portfolio volume of ISINs with available historical data for calculating the volatility as of 31/03/2021

The portfolio data with unavailable information will be proxied.

ii. Data building

As for the traded volume, the volatility calculation process will be performed by the IPV team.

For some products, like fixed income, when processing the series, some data cleaning might be needed and, in order to enrich the proxies, the pool of all references available in AC (greater than those with an open position in the portfolio) is considered, retrieving the prices and certain static data fields (normally qualitative information) used for segmentation purposes.

Once the historical price series are provided, the daily-logarithmic-return series are calculated for each ISIN:

$$return_t^{ISIN} = ln\left({Price_t^{ISIN}} \Big/ {Price_{t-1}^{ISIN}} \right)$$

Where $return_t^{ISIN}$ is the logarithmic daily return on day t and price $Price_t^{ISIN}$ refers to the observation on time t for the historical series of prices of ISIN $ISIN$. The lognormal return is assumed as to align the return with the ones calculated in other risk metrics, such as VaR.

As the data could be corrupt for a number of observations in the series, a data cleaning process must be performed. For instance, prices varying from standard price levels to zero and back to standard price levels in consecutive days are observed. The data cleaning process is performed over the return series (not over the original prices data) and consist of deleting the returns generated by zero prices (i.e., those generated by either dividing by zero or by calculating the natural logarithm of zero). Once the historical series of logarithmic-returns is calculated and filtered, the standard deviation of those returns is calculated per ISIN, and this will be the assumed one-day volatility for each instrument.

$$\sigma_{ISIN} = std(\{return_t^{ISIN} : \forall t \; \exists return_t^{ISIN}\})$$

Where σ_{ISIN} represents the one-day volatility and $\forall t\ \exists return_t^{ISIN}$ means any t where the return on date t for that ISIN has not being removed because being corrupt.

Buckets are defined by grouping products with similar characteristics. For those without data, their volatility will be proxied as the percentile 50 of the volatilities obtained for those positions with data included in the same bucket.

Notwithstanding all the above, due to data availability constraints, the prices frequently remain constant during the whole month. For this reason, in some cases monthly returns are used, rescaling after the obtained volatility to transform it from monthly to daily.

From the one-year data, 11 monthly logarithmic-returns and the standard deviation of them are calculated with the same expressions shown above. Again, the returns are assumed to be lognormal as per consistency with other risk metric models. The standard deviation obtained is rescaled as usual with the square root of the period considered. In this case, the volatility obtained with the monthly returns is rescaled dividing by the square root of the average number of business-days in a month (assumed to be 250/12). This transformation with the square root of the return-period is acceptable under the lognormal return assumption.

$$\sigma_{1D} = \frac{\sigma_{1M}}{\sqrt{\frac{250}{12}}}$$

3.4 Market access percentage

i. Data capture

One of the model inputs which should be deducted from the historical observed activity, and each unit should study the best fitting parameter, is the market access percentage. This is, of all the traded volume of the instruments subject to having an AVA adjustment per concentration, how much of it can Santander have access to when closing or hedging a position. Note that for this propose, volume should be converted to €.

To do so, and due to the difficulty of measuring this parameter, only Bloomberg data has been used, but additional sources could be considered, such as IHS Markit, clearing houses, etc. Obviously, Bloomberg does not summarize the whole market. However, it is the greatest trading platform, and its data can be considered a good reference of most of the market. Besides, using only data source has the advantage of using comparable values. Therefore, the projected percentages will be comparable.

As mentioned above, the obtainment of the market access data is very dependent on the unit, although this parameter must be determined for every desk in order to execute the tool. Each unit should aim to calibrate a market percentage for each type of product, with as much granularity as possible, and as faithfully to the unit's activity as possible.

For instance, in the case of Bonds in Boadilla SCIB, several Bloomberg reports are obtained through the "E-commerce" department. In the case of Madrid, it is classified in corporate, financial, covered debt, and sovereign debt, where Spanish, European and non-European are distinguished. These reports compare the unit's behavior in terms of volume, number of executed trades, etc., versus other anonymous competitors, as well as versus the total market.

For the different sectors, these are the volume ratio (e.g., for Corporates, the volume traded by Santander in Corporate bonds, compared to the total volume of the market in Corporate bonds) and reference ratios (e.g., for Corporates, the number of references or number of different

Corporate bonds traded by Santander compared to the total number of references traded in the market, in Corporate bonds).

Sector	Volume ratio	Reference ratio
Corporates	0.51%	4.13%
Financial	1.99%	8.04%
Covered	4.80%	47.00%
SPGBs	100.00%	100.00%
Sovereign debt EUR	0.90%	10.40%
Sovereign debt ex-EUR	2.93%	10.40%

Table 3: Volume and references ratios for Boadilla as of 31/03/2021

The SPGBs volume and reference ratio is not informed, as, due to the condition of being a market maker, the data is not necessary for calibrating the market access percentage. Additionally, the sovereign debt for EUR and ex-EUR was not provided, thus it was assumed an average value given by the Santander number of references in every segment divided by the total number of references in the market.

Dividing the volume ratio by the reference ratio the following final market access figures are obtained:

Sector	Market percentaje
Corporates	12.25%
Financial Institutions	24.71%
Cover_Bond	14.17%
SPGB	8.65%
Governments EUR	8.65%
Governments	28.16%
Others	16.80%

Table 4: Final market percentage access figures as of 31/03/2021

ii. Data building

The calculation is based on the relative traded volumes executed by Santander in comparison with the total traded volumes observed in the mentioned reports, except for ABS, in which is set to 100% due to the nature of the volumes used; and for the Spanish sovereign debt desk, in which is also 100%, as being market maker. However, as the market operates a wider list of references than Santander does, the previous ratio is adjusted according to this fact:

- Calculate the ratio between Santander traded volume versus the total market traded volume.
- Calculate the ratio among the number of products (number of references) traded by Santander versus the total number of references traded in total.
- All these numbers are extracted, for instance, from the reports obtained by E-commerce from Bloomberg, but additional sources could be considered, such as IHS Markit, clearing houses, etc.
- The market access percentage will be finally defined as the quotient between the relative volume traded by Santander and the relative number of references traded by Santander (in both cases "relative" means compared with the total market collected in those reports):

$$\%Access_{Desk} = \frac{Traded\ Volume_{Santander} / \sum_{i \in \{Market\ Participants\}} Traded\ Volume_i}{Traded\ References_{Santander} / \sum_{i \in \{Market\ Participants\}} Traded\ References_i}.$$

3.5 Static data

A critical information in order to build the proxies is the static data used for classifying the instruments in different buckets according to their characteristics (the segmentation variables are further discussed in the Model Theory Documentation *[3]*). This data is usually captured by AC (normally from Bloomberg but other sources are possible) and certified by the Market Data Team. As for the market data, the static data will be provided by the IPV team.

i. Data capture

For the whole pool of instruments available in AC, the following information is considered: country, market sector, issued currency, industry group, region, maturity and rating as issued by S&P, Moody's and Fitch. If the rating information of the position is missing, the issuer rating, also retrieved from AC, is used (if available).

ii. Data building

For bonds, the input static data will be taken from the Bonds FVA/AVA calculator already built. This will allow to align the inputs used in both methodologies, while also reducing the amount of data to process in the calculator. For ABS, the static data will be the same as the one used for ABS FVA/AVA calculator.

Once the data has been provided, the volatility and average daily traded volume in EUR currency is included to the generated table per ISIN in a separate step as to calculate the proxy values.

The bucket identifier will be the concatenation of several keys, like rating, term to maturity, mapped industry or issued currency. Higher level (less granular) proxies might be defined as fallback removing one category or more, starting from the last one mentioned (the less granular proxies considered would attend only to the rating classification).

3.6 Manual inputs

In addition to the inputs mentioned above, manual inputs can be provisioned in the tool. In this regard, certain rules should be considered in order to allow to perform some calculations.

Columns containing the ISIN, traded volume, market percentage, notional, currency, volatility, reference price and base input must be always filled.

The adjustments may be distributed by country, book, desk, accounting portfolio, entity or portfolio. The distribution level is parametrized by the user in the Bonds'/ABSs' model, and informed the tool through the distributed adjustment model output files of each model. The column corresponding to the selected distribution level must be filled too.

For instance, if the Bonds and ABSs adjustments have been distributed at *portfolio* level, the *portfolio* column in the manual inputs file must be filled.

The manual input expected structure is the following,

ISIN	Traded volume	Market percentaje	Notional	Currency	...
Instrument_1	10,000.00	25	15,000.00	EUR	...
Instrument_1	10,000.00	25	20,000.00	EUR	...

...	Volatility	Reference price	portfolio	Countries	...
...	0.0015	110.00	Porftolio_1		...

...	Volatility	Reference price	portfolio	Countries	...
...	0.015	110.00	Porftolio_2		...

...	book	desk	accounting_portfolio	entity	base input price
...					100
...					100

Table 5: Manual input feeding architecture

The columns are detailed below,

- ISIN – Instrument ID
- Market percentage – Percentage of traded volume to which the unit has access to
- Notional – Instrument position to which the adjustment should be calculated
- Currency – Currency in which the traded volume and notional are provided
- Volatility – Historical standard deviation of the instrument price
- Reference price – Internal Santander price, from which the prudent price will be generated
- Portfolio - Hierarchical aggregation used to differentiate trades. More granular than book.
- Countries – Hierarchical identification used to determine the instrument's issuer country
- Book - Hierarchical identification used to differentiate trades. More granular than desk.
- Desk – Hierarchical identification used to differentiate trades.
- Accounting portfolio – Hierarchical identification used to differentiate the accounting categorization of the transactions.
- Entity – Indicates the transaction owner.
- Base input price – Price per notional unit.

As explained in the model theory document (*[4]*), the provided data will substitute the available data when the ISIN combination is found within scope. Else, every field must be filled, and the adjustment will be calculated for these inputted positions.

This methodology allows the user to calculate concentration adjustments to additional instruments, other than bonds or ABS. By inputting an instrument identificatory in the ISIN field, and the portfolio to which the instrument belongs to, the instrument may be identified. Then, with the provided additional fields the adjustment may be calculated and will be included in the output report. This feature may be used to calculate concentration adjustments to other instruments, such as equities or CDS.

4 MODEL CONFIGURATION

There is an extra Input file that has not been mentioned in the Inputs section, as it is considered more a configuration file, more than an input file. This is an Excel spreadsheet file, named "*tool_parameters_Concentration.xlsx*". This is common in different AVA models. However, the information contained there depend on the case. In this section, the file for Bonds and ABS will be described.

The following fields must be included in the file. Only one tab (no specific name required for it, but it should be located the first in the book) is to be read. The values used as of model development date are shown as an example.

Field	Value	Description
path read	C:\Users\xxxx\Input	Path from where to read the defined inputs
path write	C:\Users\xxxx\Output	Path where to load the outputs
execution date	30/09/2021	Model execution date
print out	TRUE	Whether or not to print intermediate outputs
print steps	TRUE	Whether or not to inform through the console of the steps given by the tool
Issuer proxy	TRUE	Whether the issuer proxy is applied
ABS included	TRUE	Whether or not to inform if ABS should be included
reporting currency	EUR	Notional, aggregated volume, etc. will be evaluated in this currency
base input price	100	Price per unit of notional
exchange rate file	exchange_rate.csv	File containing the exchange rates
exclusions file	Exclusiones_concentracion.xlsx	File containing the ISINs excluded from the calculation
exemption file	Excepciones_concentracion.xlsx	File containing the ISINs not subject to the concentration adjustment, if in scope
market access percentajes	acceso_mercado.xlsx	File indicating the marke access percentaje per industry
bond volatility file	volatility_bonds_20210930.xlsx	File with the volatilities per ISIN for bonds
bond volume file	volume_bonds_20210930.xlsx	File with the average traded volume per ISIN for bonds
bond volume currency	EUR	Currency in which the bond volumes are provided. If "native", each ISIN will be assumed to be provided in its own currency
ABS volatility file	volatility_abs_20210930.xlsx	File with the volatilities per ISIN for ABS
ABS volume file	volume_abs_20210930.xlsx	File with the average traded volume per ISIN for ABS
ABS volume currency	native	Currency in which the ABS volumes are provided. If "native", each ISIN will be assumed to be provided in its own currency
bonds user inputted changes	bonds_inputs_adjustment.xlsx	File indicating average traded volumes, alternative from the volume files already described
bond static data	Rating_bonds.xlsx	Output from the bond calculator. File with static data per ISIN for bonds.
ABS static data	ABS_StaticData_AC_20210930.xlsx	File with static data per ISIN for ABS.
ABS model output	FVAs & AVAs report.xlsx	ABS model calculator output
Bond model output	AVAs_FVAs_Bonds_Exempt.xlsx	Bond model calculator output
Market making condition	market_making.xlsx	Contains information to determinate the market making condition
Bonds proxy fallback	proxy_fallback_bonds.xlsx	Rating used for that bonds with no rating informed

Field	Value	Description
ABS proxy fallback	proxy_fallback_abs.xlsx	Rating used for that ABS with no rating informed
ABS user inputted changes	ABS_inputs_adjustment.xlsx	File indicating average traded volumes, alternative from the volume files already described
marginal distribution bonds	marginal_distribution.xlsx	File containing the level which will be used to calculate the adjustments per level for bonds
marginal distribution ABS	marginal_report.xlsx	File containing the level which will be used to calculate the adjustments per level for ABS

Table 6: Configuration input description

5 MODEL IMPLEMENTATION

This section contains all the technical information about the implementation and the exact treatment of specific functional details as interpolations in market data, proxy calculation and the algorithm to apply calendars.

5.1 Model Architecture

The functional architecture of the Concentrated Positions AVAs model is presented in the figure below:

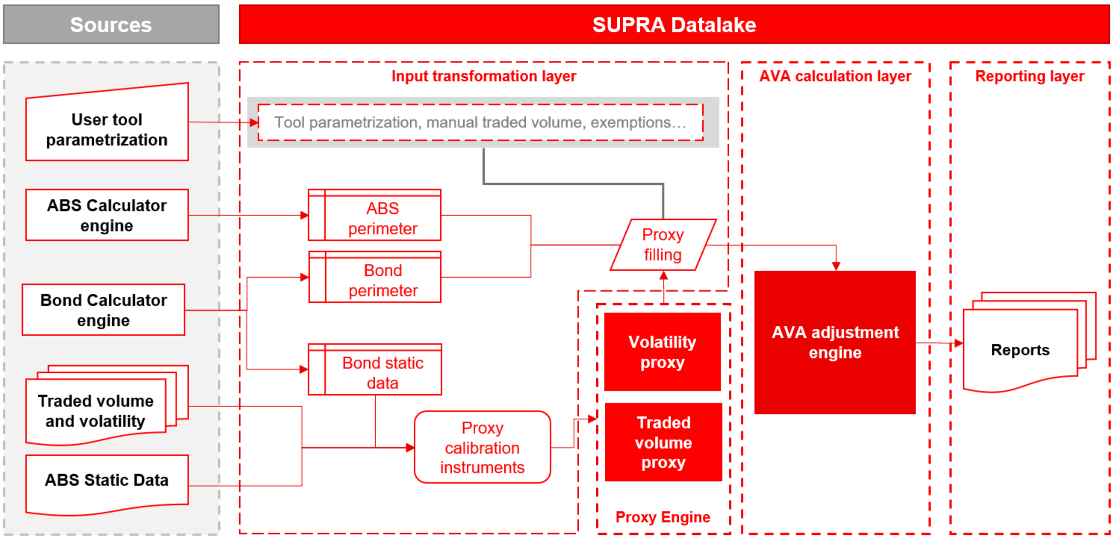

Figure 4: Functional architecture of the Concentration AVA model

As it can be seen, the main parts of the architecture are the following:

1. **Input Data**: Data feeding to the tool. The used sources which generate the inputs for calculating the concentration AVA adjustment are AC, Markit and Bloomberg.

    a. AC: In-house official data warehouse, and it is where the portfolio instrument's information -such as the notional or the mid-price- and static instrument data -maturity, rating, currency, among others- is provided. This is Santander's golden source for instrument prices and general market data. Different instruments are identified by a unique code known internally as ADO.

    b. Markit: This data provider supplies monthly bond related data, with information such as quoted price or traded volume, among others. This has been seen to be the best data source for retrieving bond information as for the exercise performed in Madrid, although any other source with as much granularity and information as the Markit files could replace the current provider data if fits best the local market needs.

    c. Bloomberg: Well-known data provider and trading platform, among others, where ABS data are downloaded. The same as Markit for bonds, this has been seen to be the best market data for ABS as for the model development exercise in Madrid. However, any other source with as much detail as the Bloomberg retrieved information could be used instead if fits best the local market need.

The sources named above are the sources used as in model development date. However, the different inputs could be provided from any other source, if it is provided in the format defined below.

2. **Proxy**: This is an additional engine that processes the input information and generates the proxy values. Then, it checks the instruments with position in the portfolios and if any required information is missing, it is proxied within this layer. This is a previous step that is aimed to prepare the instruments dataset that feeds the AVAs engine.

   It is to keep in mind how a minimum number of observations must be provided per proxy bucket, and therefore enough information should be given for performing the proxy filling.

3. **Concentration AVA calculation engine**: Core of concentration AVA calculation. The engine performs the required calculus and includes in the dataset the generated variables required for each step of the process.

4. **Reporting layer**: includes the intermediate and final reports generated, together with an error log used to verify whether any issue has been detected through the model execution.

Currently the model is implemented in Python with data inputs and outputs in comma separated values files (.csv extension) or Excel files. In the future, the strategical architecture will be implemented in SUPRA Data Lake. All the information required will be read either from already existing SUPRA databases or will be upload to a specific working space for this process.

The following paragraphs describe details and evidence from the analysis of model implementation used for the Concentration Positions. The information has been particularly defined for fixed income securities, being a particular case of the total scope of Concentrated Positions. However, it should be noted that this is a specific example for fixed income products, but the analysis could also cover other positions.

5.2 Technical implementation

This section has been divided into five different sub-sections that enables the understanding of the logics behind the implementation:

1- Data feed and transformation;
2- Proxy generation;
3- Missing data filling;
4- Portfolio manual input customization;
5- AVAs Calculation;
6- Reporting.

The different steps of the model are executed in 7 different modules developed internally, besides the use of industrial python modules such as Numpy or Pandas:

- *AVA_Model_Concentration.py*, from where the process is executed.
- *do.py*, where the main calculus is structured and executed.
- *fun_ajuste_AVA.py,* where the module for calculating the AVA adjustment once every field has been correctly loaded is located.
- *fun_group_by_proxy_v3.py,* where the module aggregating per key, i.e., performing steps defined in 5.2.2**¡Error! No se encuentra el origen de la referencia.**, is located.
- *fun_read_inputs.py,* where the data feeding modules are located, and the process is structured.

- *fun_volatilidad.py,* where the volatility is generated, and corrupt returns are filtered after the historical price series.

For executing the code, the *tool_parameter* file must first be properly parametrized.

5.2.1 Data feed and bucketing

This sub-section details the features of the necessary inputs and its format to be fed into the model. To calculate the adjustments, data about the portfolio, prices and historical prices need to be uploaded. To develop the present methodology, data from AC, Markit and Bloomberg has been considered.

The following description includes the file names used as of the code development date. However, these names can be parametrized and must not be considered as mandatory names for the input files.

5.2.1.1 Portfolio information

The scope of the AVAs and FVAs adjustments does not include all the Bond positions shown in SUPRA Data Lake. The scope must be defined according to the accounting category of each position, given by the portfolio where the trade is located[6]. Only those portfolios categorized as Fair Value must be taken into consideration. As to minimize the error when executing the concentration tool, the perimeter subject to the concentration AVA will be obtained from the ABS and Bond calculator output, respectively for ABS and Bonds. For a greater detail on the model outputs, please refer to its own documentation.

From these outputs, the following columns are required. This could be of use if, for instance, the concentration tool was to be executed for a different set of instruments. For Bonds, the following columns are required:

portfolio	ticker	Currency	Nominal Vivo	Industry	MarketMaking
COVERBONDS	XS1318364731	EUR	12,108,000.00	Cover_Bond	

Table 7: Fields considered from Bonds output

On the other hand, the following columns are requested for ABS:

desk	ISIN	currency	Precio_AC	Sum of Nominal Vivo
ALL_DESKS	ES0305248009	EUR	100.23	2,133,862.20

Table 8: Fields considered from ABS output

5.2.1.2 Static data

As it has been already detailed in the methodological section, the static data will be used for generating the proxy values and will determine which proxy to apply. A pool of instruments big enough must be provided to be able to fill the missing information. As of model development date, the static data for bonds and ABS was retrieved from AC and Bloomberg.

For Bonds, the inputted static data must be the one outputted from the *FVA/AVA Bonds* calculator, in file *Rating_bonds.xlsx*. Within this process, the static data will be bucketed or categorized into

[6] The portfolio where the trade belongs to, determines the accounting category. This way two trades on the same ISIN could have different accounting categories. The nominal to be considered for a particular ISIN is only the one of the trades within the required accounting category.

greater keys. To guarantee that the used data is identical for both metrics, the used static data will be inputted.

This static data is extracted from several sources, like Bloomberg or Reuters. As proxies will be defined according to those categories, they should be granular enough to identify specific but homogeneous behaviors. On the other hand, the granularity must not be excessive; otherwise, we would not be able to find enough Bonds (with data available) to populate sufficiently all the categories and therefore, we would not be able to build consistent proxies for each bucket.

Therefore, the columns found within this file would be the following:

Field	Example	Description
ISIN	ES0000000001	ISIN identifier code
acprice	109.22	Base-100 price as loaded in AC
is_covered	N	Y/N, indicating if the instrument is a cover bond
industry	Banks	Instrument industry
maturity	17/07/2023	Instrument maturity date
country	FRANCE	Country where the instrument is issued
issuer	CREDIT AGRICOLE LONDON	Issuer of the instrument
currency	EUR	Currency in which the instrument has been issued
parent_company	CREDIT AGRICOLE SA/LONDON	Issuer of the instrument
region	Europe	Region in which the instrument has been issued
rating	AAA to A	Tranched instrument rating
issuer_rating	AA	Internal rating of the issuer
ORIGINAL RATING	A	Internal instrument rating
Area	Europe	Region in which the instrument has been issued
COMB_IND	Financial Institutions	Coded instrument industry
COMB_REG	Europe	Coded instrument region

Table 9: Bond static data input fields

In the case of concentrated positions, the outputs described in the table above are taken as inputs to take advantage of the treatment applied in the case of bonds, which can be consulted in their specific documentation *[5]*.

In the bond calculator, through the function *rating_builder,* the algorithm creates the categories in which all the ISINs will be classified. All the available ISINs in Asset Control are taken into consideration, labeling each bond depending on Region, Sector (because of their special nature, covered bonds are treated as a particular sector) and Rating. The required field mapping is detailed below,

- <u>COMB_REG:</u> Field *region* is mapped to *Europe*, *North America*, *LATAM* or *Other*; <u>COMB_IND:</u> The column *industry* is mapped to *Financial Services*, *Governments* or *Cover Bond*;
- <u>rating:</u> The rating is grouped to greater tranches, *AAA to A*, *BBB to B* or *CCC to D*. This column will substitute the original rating value loaded, which will be stored in column *ORIGINAL_RATING*.

On the other hand, for ABS static data, the following columns must be given, which would be the same columns as the ones inputted in the ABS tool.

Field	Example	Description
ISIN	ES0000000001	ISIN identifier code
acprice	98.9128	Base-100 price as loaded in AC

Field	Example	Description
instrument_type	Whole Loan	Instrument type
most_senior_indicator	Y	Y/N, indicating the highest seniority indicator
industry	WL Collateral CMO	Instrument industry
maturity	15/07/2042	Instrument maturity date
country	SPAIN	Country where the instrument is issued
issuer	Santander Hipotecario	Issuer of the instrument
currency	EUR	Currency in which the instrument has been issued
parent_company	ASF SANTANDER HIPOTECARIO 1 1 A	Issuer of the instrument
region	Europe	Region in which the instrument has been issued
rating	AA	Internal instrument rating
issuer_rating	AAA	Internal rating of the issuer
product_type	ABS	Product type, ABS/Bond

Table 10: ABS static data input fields

First, the columns regarding maturity, industry and region for each ISIN is added to the portfolio information detailed in subsection above. This are the required fields to generate and apply the proxies in case that any data is missing.

As in the case of Bonds, a summary of the inputs requiring treatment in the case of ABS is as follows (for more information, refer to the specific Bond and ABS documentation *[5]*):

- Credit worthiness of the ABS – This is driven by a structural factor that is the priority level of the tranche in the whole securitization and the performance of the pool. This can be represented with the updated credit rating of the tranche.
- Type of securitization and/or type of collateral – These features may affect the uncertainty level and market appetite. The securitization type is different if the underlying pool is defined with real assets or synthetically through CDS (CDOs) or another bonds (CBOs).
- Region in which the issuer operates – No critical differences related to this aspect are expected, as securitization sector is only developed in mature economies.
- Expected maturity (considering prepayments) – It is only relevant for very specific scenarios: mezzanine tranches which are expected to be affected by defaults and bonds very high premiums or discounts above par (which might be only the case where from the date of issuance and present date a structural change in the market has happened).

5.2.1.3 Volume file

An additional input required for the tool execution would be the daily traded volume file. This file indicates, per ISIN, the expected average daily traded volume. This input should be provided with the following structure:

ISIN	avg_daily_traded_volume
ARALUA560013	52,958.56

Table 11: ABS and bonds volume file structure

This format should be provided as shown for bonds and for ABS, and these are to be provided in different files.

These volumes should be converted to EUR currency.

5.2.1.4 Volatility file

The final input required for performing the calculations is the volatility file. As for the volume file, it should indicate, per ISIN, the historical volatility in one-day terms. The Excel spreadsheet should have the following structure,

ISIN	volatility
ES0000011868	0.0028

Table 12: ABS and bonds volatility file structure

As for the volume file, the same structure is required for bonds and ABS, which should be provided in separate files.

5.2.1.5 Market making

This is used to indicates that bonds that have 100% of market access for their market making condition. The format should be the following:

Fill	Value
issuer	REPT
issuer	8RES
issuer	BESP

Table 13: Market making file structure

In the column "Fill", issuer or ISIN can be chose and the column "Value" should be completed according to the option selected.

5.2.1.6 Tool parametrization

For a greater detail on the tool parametrization input, please refer to section 0 for a detailed description of the expected inputs and the file structure.

5.2.2 Proxy generation

Once all the information is fed to the tool and modified as required, the proxies must be built in order to generate the values which will be used to replace the missing values required for the calculation.

Two different type of proxies could be applied, the issuer proxy and the bucket proxy. Both will be generated with the total pool of instruments with data available (so it is not restricted with an open position). This choice is in order to have a larger number of observations to develop the as proxy for each bucket.

The issuer proxy will be applied in a first instance to fill volume missing values. For each issuer, the percentile 50 of the volume is obtained and assigned for that bonds with no volume data.

If the issuer proxy is not available or has not been developed for a certain position, the bucket proxy will be used instead. This part of the calculation is performed completely on module *fun-_groupby_proxy_v3.py*. For this purpose, the static data (see section 3.5) is to be merged with the volume (see section 3.2) and volatility data (see section 3.3) beforehand. Once all the data is aggregated, the bucket proxy can be developed. The methodology is applied followed a predefined hierarchy, so the following steps are followed:

First, the percentile 50 is calculated for every instrument with the same rating. Then, the percentile 50 is calculated for every instrument with same rating-maturity, rating-maturity-industry and rating-maturity-industry-currency. Together with the percentile, the number of observations used for building each middle value is kept.

Two different parameters are required for calculating this middle value besides the percentile level. First, in order to calculate the proxy, it has been decided to exclude the missing values from the Markit files for the calculation, where a minimum of 4 observations must be granted.

The following parameter to define would be whether to consider or not the observations which have zero values. The reason for including this parameter in the model development is that the missing values which affect the calculation are the average daily traded volume and the volatility, two variables which by definition must be greater than zero. An issue arises when, due to chosen input data, some instruments could have an average traded volume equal to zero, for instance, and therefore a corrupt value would modify the bucket middle value.

This parameter should be set according to the input data quality and construction, and it was set to omit the zero values as of model development date.

Once the bucket middle values have been correctly obtained, one may now apply these to the portfolio information.

5.2.3 Missing data filling

The proxies have already been calculated, and therefore the missing values can now be filled with bucket data. This process will be performed within the tool. In order to guarantee that the chosen value is representative enough, one may define a minimum number of observations per bucket in order to assume that the bucket value is valid and representative of the instrument sharing the same keys. For instance, if an instrument of a bucket has missing volatility due to input limitations, and the volatility calculated for the bucket is composed by only two values, it could be the case that the model user may interpret this value as not representative.

Therefore, if the minimum number of observations is not reached, a fallback would be applied. This is, for an instrument pertaining to a bucket given by four concatenated keys where the corresponding bucket does not meet the minimum requirements to be considered representative, the value which will be assigned will be the value of the bucket sharing the first three keys instead. The dropped key is intended to be the least relevant one.

This process will be performed over again until the last key is reached. If this value is not available either, an error will be loaded to the error log, and the remaining value will be set to be the value of the most punitive proxy available. This would imply that the input data might not be granular enough, or that a greater number of observations should be collected in order to generate a representative bucket middle value.

For every bucket fulfilling the minimum data requirement, the null or zero value will be replaced instead to the one given by the bucket, and therefore now the calculus can be performed.

5.2.4 Portfolio manual input feed

The tool includes a feature where the user may manually insert any of the following data: average daily traded volume, volatility, portfolio, book, desk, country, entity, accounting portfolio, base input price, currency, reference price and the market access percentages values. If it is the case, obtained automatically is overwritten by the data inputted manually or the proxies generated from them.

Manual input feed has to be only used when the model user considers that these better represent market conditions or some data issues need to be fixed (e.g. insertion of additional instruments/positions) so it has to be properly justified.

When manually inputting a new instrument and the level at which the user wants to distribute the calculation, the new position will be added in the portfolio scope and the AVA calculation will include it. Note how, in this case, the following data is required: traded volume, market percentage, notional, currency, volatility and reference price.

If the position was already in portfolio scope, the data inputted will overwrite the data that was originally uploaded in an automated way.

5.2.5 AVA calculation

In order to calculate the Concentration AVA, the formula defined in the Model Theory Documentation ([4]) is applied. To do so, the minimum set of information required to perform it is: the ISIN, notional, price as loaded in AC, average daily traded volume and the price standard deviation.

After the concentration AVA has been calculated at an aggregated level, the adjustments may be distributed at certain level. This level may be country, book, desk, accounting portfolio, entity and portfolio. It is to highlight how the distribution level must be equal to the one specified in the bond and ABS MPU/CoC model, and how the distributed output files (marginal_distribution.xlsx and marginal_report.xlsx, for bonds and ABSs respectively) are to be provided to the tool. More information on these files can be found in section 5.3.1.

For instance, the following table presents an example of the Bonds distributed output file generated using *portfolio* as distribution level:

ticker	portfolio	Currency	Nominal Vivo	FVA CoC dist	FVA MPU dist
ARARGE03H413	ESUM_UNMINSECUN	USD	0	0	0
ARARGE03H413	NYCR_SOVA	USD	-19,990.40	387.90	-81.42

Table 14: Fields contained in the Bonds output

On the other hand, the ABSs distributed output file contains the following information:

ISIN	portfolio	Sum of Nominal Vivo	FVA dist	FVA All dist
ES0312344015	ESACPM_INV_ABS	2,899,386.00	-188.46	-188.46
ES0312872015	ESACPM_INV_ABS	1,944,276.57	-2,974.74	-2,974.74

Table 15: Fields contained in the ABSs output file

5.2.6 Reporting

The tool calculation generates a series of output reports, which can be used verifying that the different steps of the model have been correctly executed as well as for a better understanding of the final figures.

First, the bond and ABS assigned values for each ISIN, are printed in files generated in the output directory, with names *bond_proxies.xlsx* and *ABS_proxies.xlsx* respectively for the proxy calibration instrument pool, and *df_price_bonds.xlsx* and *df_price_abs.xlsx* for the portfolio information. The average values used as proxies per bucket, as described in 5.2.2, are printed in output files *df_proxy_gb_bonds.xlsx* and *df_proxy_gb_abs.xlsx*.

The final figures per instrument type are saved in *df_bonds_AVA.xlsx* and *df_abs_AVA.xlsx* respectively. These files will store the information at position level resulting from the full processing of the AVA calculation. In addition, the files *df_bonds_AVA_distributed.xlsx* and *df_abs_AVA_distributed.xlsx* contain the AVA figures distributed between the different portfolios (or the level specified by the issuer instead) for each instrument. Bonds or ABSs with no information relative to ISIN, currency or AC price does not appear in these outputs. They are saved in *Bonds_missing_values.xlsx* and *ABS_missing_values.xlsx* respectively.

Finally, the last report generated is the summary report log, outputted as *summary_report_log.xlsx*. This file summarizes the process output and will always be generated. Besides printing the output aggregated figures for concentration for bonds and ABS, a summary of, which files were considered, which files were printed, or the configuration chosen for certain functions, among others, is printed.

5.3 User guide

The purpose of this section is to provide an explanation of the functioning of the model, so that a third party can handle it without support from the developers. The main difficulty comes from the Excel and CSV files needed. For this reason, the section focusses on those needed and its interaction with the user.

5.3.1 Preparing the input data

Several input files must be provided as to execute the model correctly. There are files required only for the bond adjustment calculus, only for the ABS adjustment calculation or for both:

Bond input files

- *Bonds_StaticData_AC_20210129_ModelOutput.xlsx*: Static data output from the *FVA/AVA Bond* calculator.
- *AVAs_FVAs_Bonds_Exempt.xlsx*: FVA/AVA Bond calculator model output as of model execution date.
- *volume_bonds_20210129.xlsx*: Average traded volume per ISIN for bonds.
- *volatility_bonds_20210129.xlsx*: Volatility per ISIN for bonds.
- *Market_making*.xlsx: Indicates where the market making condition apply.
- *marginal_distribution.xlsx:* Includes the category which will be used to distribute the adjustments at different levels

ABS input files

- *ABS_StaticData_AC_20210129.xlsx*: Static data for ABS.
- *FVAs_&_AVAs_extended_abs.xlsx*: FVA/AVA ABS calculator model output as of model execution date.
- *volume_abs_20210129.xlsx*: Average traded volume per ISIN for ABS.
- *volatility_abs_20210129.xlsx*: Volatility per ISIN for ABS.
- *marginal_report.xlsx:* Includes the category which will be used to distribute the adjustments at different levels

Common concentration input files

- *Tool_parameters.xlsx*: Master file, indicating the names of the files to consider when executing the model for the different calculations.
- *acceso_mercado.xlsx*: Per portfolio, which market access will be granted for calculating the corresponding adjustment.
- *Excepciones_concentracion.xlsx*: List of ISINs to exclude from the calculation. A zero adjustment will be assigned to those ISINs.
- *exchange_rate.csv*: Model execution date exchange rates between the currencies conforming the portfolio and a consolidation currency (currently set to EUR).

- *inputs_adjustments.xlsx*: Allows the user to input manually average traded volumes and the market access percentages to different instruments.

5.3.2 Executing the code

No particular folder structure is required to execute the model, as it is easily parametrizable from the *tool_parameters* file. However, as of model development date, the following folder structure was chosen.

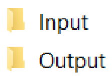

Figure 5: Folder structure

The code and the *tool_parameters* were defined to be in the same level where the Input/Output folders are.

- **"Input":** Directory containing the input data files as stated in previous section (see Section 5.3.1).
- **"Output":** Directory where to store the outputs generated through the execution.

The code files are:

- *AVA_Model_Concentration.py*, from where the process is executed.
- *do.py*, where the main calculus is structured and executed.
- *fun_ajuste_AVA.py,* where the module for calculating the AVA adjustment once every field has been correctly loaded is located.
- *fun_group_by_proxy_v3.py,* where the module aggregating per key, i.e., performing steps defined in 5.2.2, is located.
- *fun_read_inputs.py,* where the data feeding modules are located, and the process is structured.
- *fun_volatilidad.py,* where the volatility is generated, and corrupt returns are filtered after the historical price series.

In order to run the model, once we have the folders and data ready, it is necessary to open the main python file, *AVA_Model_Concentration.py*, and execute it from the Python environment (e.g., Spyder, Pycharm, etc.).

The automation has been done in Python, and it has been developed under version 3.7.1. Note how several Python industrial modules are used throughout the code, and the following should be guaranteed to be found on the PYTHONPATH route.

- Pandas (version 0.23.4)
- Numpy (version 1.15.4)
- Scipy (version 1.4.1)
- Pickle (compatible version)
- Scikit-learn (version 0.20.1)
- Openpyxl (version 3.0.6)
- Xlrd (version 1.2.0)

Additional modules such as *re* or *os* as required, although the remaining non-cited modules are by default found within base python. The above-named modules will be installed with the download of the Anaconda Python.

6 REFERENCES

[1] Fair_Value_Adjustments_Methodological Standards_v3, Market Risk Methodology, May 2018

[2] Additional Value Adjustments (AVA) _ Methodological Standards, Market Risk Methodology, Nov 2018

[3] "IPV_sep18", IPV Team, Jun 19

[4] FVA_AVA_Concentration_ModelTheory, Methodological Standards, April 2021

[5] FVA_AVA_Bonds_ABS_ModelImplementation, Methodological Standards, April 2021

7 CHANGE CONTROL

Version	Owner	Changed by	Date of change	Validated by	Committee approval	Approval date	Scheduled review date
1	Pablo Blanco	Ignacio Hoyos	12/07/2020	Elena Lopez		16/07/2021	
2	Pablo Blanco	Ignacio Hoyos	03/01/2022				

Version	Description of change
1	Initial version
2	a) Issuer proxy included for average traded volume inference b) Marginal distribution allowed per category/level c) Manual input file included with additional parametrization options