Index guidelines relating to the

OpenMetrics-JIMAG EUR Bonds & Precious Metals Optimized Index

ISIN: DE000A2QATB8

("**Index Guidelines**")

Version 1.0 dated 11.09.2020

IMPORTANT INFORMATION

The general principles of the OpenMetrics-JIMAG EUR Bonds & Precious Metals Optimized Index (the "**Index**") as of 11.09.2020 are set out below.

It should be noted that the general principles of the Index may be updated or amended from time to time. In managing the Index, the Index Administrator will employ the methodology described herein and its application of such methodology shall be conclusive and binding. No assurance can be given that fiscal, market, regulatory, juridical, financial or other circumstances will not arise that would, in the view of the Index Administrator, necessitate or make desirable a modification of or change to such methodology. The Index Administrator shall be entitled to make any such modification or change any of the provisions of the Index as set out in these Index Guidelines as it deems fit. The Index Administrator may also make modifications to the terms of the Index in any manner that it may deem necessary or desirable, including (but not limited to) to correct any manifest or proven error to cure, correct or supplement any ambiguity or defective provision contained in these Index Guidelines. Any such modification or change will take effect accordingly and will be deemed to update these Index Guidelines from its effective date.

This document is communicated by the Index Administrator. All information provided herein is for information purposes only and no warranty is made as to its fitness for purpose, satisfactory quality or otherwise. Every effort has been made to ensure that all information given is accurate, but no responsibility or liability (including in negligence) can be accepted by the Index Administrator for errors or omissions or for any losses arising from the use of this information.

The information presented herein has been prepared based on the publicly available information, internally developed data or other third-party sources believed to be reliable. All opinions and views constitute judgments as of the date of the writing and are subject to change at any time without notice.

Information contained in these Index Guidelines do not constitute an invitation to make an investment in a product based upon the Index (an "**Index Linked Product**") nor does the information, recommendations or opinions expressed herein constitute an offer for sale of an Index Linked Product.

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INTRODUCTION

This document contains the underlying principles and regulations regarding the structure and the operations of the Index. The Index is the sole property of the Index Sponsor. LIXX GmbH, Fürstenwall 172a, 40217 Düsseldorf, Germany ("**LIXX**") as the Index Administrator and Index Calculation Agent strives to the best of its ability to ensure the correctness of its mechanism and calculation. LIXX is not obliged – irrespective of possible obligations to issuers – to advise third parties, including investors and/or financial intermediaries, of any errors in the Index. This document is to be used as a guideline regarding the composition, calculation and management of the Index. Any changes made to these Index Guidelines are initiated by the Index Administrator.

The calculation and publication of the Index by LIXX is no recommendation for capital investment and does not purport any assurance or opinion regarding a possible investment in a financial instrument based on the Index.

1. INDEX DESCRIPTION

1.1 Summary of Index Specifications

Reference Market	**Index Objective**
Listed instruments with exposure to the European government bond market, the European corporate bond market and precious metals (the "**Reference Market**").	The objective of the Index is to reflect the performance an investor can achieve by investing in a portfolio of weighted exchange traded funds ("**ETF**") which provides an improved risk/return profile compared to a passive investment in instruments and to protect against major drawdowns during severe market crises. In order to reflect the economic reality given by factors such as availability of instruments, reinvestments of maturing instruments and portfolio size, composition of the Index and the weighting of the Index Components is subject to change (the "**Index Objective**")
Administration of the Index and Regulatory Status	
The Index is calculated, maintained, rebalanced and published by the Index Administrator and sponsored by the Index Sponsor. The Index is maintained, and rebalanced following recommendations provided by the Index Allocator. As at the date of these Index Guidelines the Index is considered a "non-significant benchmark" within the meaning of Article 3 para 1 (27) the Benchmarks Regulation. The Index is administrated in accordance with the applicable provisions of the Benchmarks Regulation and the applicable delegated regulations. The Index Administrator may, at its own discretion, choose not to apply some or all non-mandatory, waivable obligations in accordance with Article 26 of the Benchmarks Regulation.	
Universe of Index Components	
Shares in exchange traded funds (ETF) relating to the Reference Market.	

Selection of Index Components
Generally, the selection of Index Components is static. The initial index allocation can be found in **Annex 4**. However, the composition of the Index is subject to change under certain circumstances. Further information can be found in section 2.2 (*Selection of Index Components*).
Changes to Index Components (Index Allocation)
The Index Component's weightings are subject to change. The Index Administrator will adjust the Index allocation by implementing any Allocation Advice it receives from the Index Allocator. The Allocation Advice must adhere to the allocation mechanism described in **Annex 3**.
Index Methodology
The methodology of the Index is set out in section 2 *(Index Methodology)*.
Technical Specifications
The reference currency of the Index is EUR and the Index is calculated daily. The Index will not use leverage. The Index is a Total Return Net Index, i.e. dividends or coupon payments will be reinvested in the hypothetical portfolio of the Index after deducting Withholding Tax.
Data Provider
The recommendations provided by the Index Allocator are considered input data. Relevant prices used to allocate the Index Components following receipt of such recommendations are based on the Official Valuation, which is sourced from data that is readily available to the Index Administrator.

1.2 Name and ISIN

The name of the Index is OpenMetrics-JIMAG EUR Bonds & Precious Metals Optimized Index. The Index is distributed under ISIN DE000A2QATB8.

1.3 Index Start Date and Initial Index Value

The Index is established for calculation by LIXX as of 21.09.2020 ("**Index Start Date**") with an initial level of 1143.55 index points ("**Initial Index Value**").

1.4 Distribution

The Index Value is published by LIXX under a sub-page of www.lixxinnovation.com as of each Index Valuation Date, no later than twenty-five (25) Business Days following the respective Index Valuation Date.

1.5 Prices and Calculation Frequency

The Index is calculated daily on each Business Day (each an "**Index Valuation Date**"). In case a scheduled Index Valuation Date is not a Business Day, the Index Valuation Date falls on the next day that is a Business Day. The Index calculation is based on the Official Valuation of the respective Index Components. The Index Administrator will take appropriate steps to avoid a disruption to the process of the provision of the Index. However, if relevant data cannot be obtained, the Index Administrator will not publish the Index. Deficient calculations will be managed in accordance with the LIXX Correction Policy.

1.6 Index Administrator and External Service Providers

1.6.1 Index Administrator

In performing its duties, the Index Administrator follows the business principles published on its website and in accordance with the applicable provisions of the Benchmarks Regulation and its delegated regulations.

In managing the Index, the Index Administrator will employ the methodology described herein and its application of such methodology shall be conclusive and binding. No assurance can be given that fiscal, market, regulatory, juridical, financial or other circumstances will not arise that would, in the view of the Index Administrator, necessitate or make desirable a modification of or change to such methodology and the Index Administrator shall be entitled to make any such modification or change any of the provisions of the Index as set out in these Index Guidelines as it deems fit. The Index Administrator may also make modifications to these Index Guidelines in any manner that it may deem necessary or desirable, including (but not limited to) to correct any manifest or proven error to cure, correct or supplement any ambiguity or defective provision contained these Index Guidelines. Any such modification or change will take effect accordingly and will be deemed to update these Index Guidelines from its effective date.

1.6.2 Index Allocator

The Index Allocator and the Index Administrator have entered into an index allocation agreement, pursuant to which the Index Allocator may provide the Index Administrator with certain

recommendations regarding the composition of the Index. Each such recommendation must qualify as valid Allocation Advice as defined in section 12 (*Rebalancing and Allocation Advice*).

The Index Allocator provides such Allocation Advice to reflect the economics of the reference market and the Index Objective. Any Allocation Advice shall be based on the results obtained from application of the allocation mechanism described in **Annex 3**.

1.7 Publication

Specifications and information relevant for calculating the Index will be made available on the website www.lixxinnovation.com and sub-pages.

1.8 Historical Data

Historical data will be recorded in accordance with Article 8 of the Benchmarks Regulation, if and as applicable. This means that in such cases all input data and the methodology will be recorded for a minimum of five years.

1.9 Licensing

Licenses to use the Index as a benchmark for derivative instruments may be issued by the Index Administrator to stock exchanges, banks, financial services providers and investment houses.

2 INDEX METHODOLOGY

Generally, the composition of the Index is static. However Index Components may be removed from or added to the Index at the Index Administrator's discretion under certain circumstances, as described in section 2.4 (*Changes to Index Components*) and in section 3.4 (*Adjustments Following Distributions and Corporate Actions*).

Index Components must, at the time of inclusion, meet certain selection criteria, as described in section 2.2 (*Selection of Index Components*). In case of any replacement of an Index Component, the Index Administrator will publish information about a change pursuant to section 1.7 (*Publication*).

The Index Component's weightings are subject to change, as described in section 2.3 (*Allocation of Index Components*).

The Index Value will be determined based on the Official Valuation.

2.1 Universe of Index Components

The relevant categories of instruments out of which Index Components may be selected are set out in **Annex 1**.

2.2 Selection of Index Components

Out of the Universe of Index Components only such instruments that meet the Index Component Selection Criteria set out in **Annex 2** are eligible for inclusion in the Index. The initial index allocation is set out in **Annex 4**.

2.3 Allocation of Index Components

The Index Administrator will adjust the Index allocation according to any Allocation Advice it receives from the Index Allocator. The Allocation Advice must adhere to the allocation mechanism described in **Annex 3**. Therefore, the Index Components' weightings are allocated by the Index Administrator at the Index Allocator's discretion.

2.4 Changes to Index Components

The Index Administrator may, at its reasonable discretion, remove an Index Component from the Index if on any Index Valuation Date *inter alia*:

(i) Such Index Component ceases to meet the Index Component Selection Criteria;
(ii) such Index Component ceases to exist or is terminated;
(iii) purchasing, holding or selling of such Index Component becomes unlawful or economically unreasonable for a holder of such Index Component in Switzerland or the European Economic Area;

(iv) the Index Administrator deems such removal necessary to ensure that the Index continues to meet the Index Objective and composition restrictions;

(v) the Index Administrator has available to it relevant Allocation Advice instructing it accordingly;

(vi) a Change in Law, Tax Event or Regulatory Event occurs.

After removal of an Index Component the remaining Index Components' allocation may be adjusted accordingly and a replacement component that meets the Index Component Selection Criteria may be added to the Index.

A component that satisfies the Index Component Selection Criteria may be added to the Index to ensure that the Index continues to meet the Index Objective and composition restrictions. After inclusion of the new component, the other Index Components' allocation may be adjusted accordingly.

3 CALCULATION OF THE INDEX

3.1 Index Formula

On each Index Valuation Date, the Index Calculation Agent calculates the Index Value. This calculation is based on the Official Valuation.

The Index Calculation Agent will use the following formula to calculate the Index Value:

$$Index_t = \sum_{i=1}^{N} (W_{ti}\, xP_{ti}) - A_t$$

Whereas:

$Index_t$ is the Index Value at time t.

W_{ti} is the number of units of an Index Component in the Index at time t.

P_{ti} is the Official Valuation of each Index Component at time t > 0.

A_t is the adjustment factor, which is determined at the reasonable discretion of the Index Administrator at the time t with reference to adjustments carried out pursuant to sections 3.3 (*Other Changes*) and 3.4 (*Adjustments Following Distributions and Corporate Actions*).

N is the total number of Index Components.

i is representing an individual Index Component.

3.2 Accuracy

The value of the Index will be rounded to two (2) decimal places (with halves being rounded up). Calculations on units are rounded to eight (8) decimals (with halves being rounded up).

3.3 Other Changes

The Index Administrator may at its reasonable discretion amend these Index Guidelines to (i) ensure achievement of the Index Objective or (ii) to address any errors, omission or ambiguities. Such amendments may include changes to the Index Component Selection Criteria or the rules with respect to the composition, calculation and weighting of the Index.

3.4 Adjustments Following Distributions and Corporate Actions

3.4.1 Dividends

Dividends, interest and other distributions will be allocated to the Index. A Withholding Tax is applicable and will be deducted, before the corresponding unit size of an Index Component is adjusted.

3.4.2 Corporate Actions

In case of a corporate action on an Index Component, the Index Calculation Agent will assess whether such corporate action has a dilutive or any other effect on the price of the Index Component. In such case, the Index Calculation Agent will make required adjustments and determine the date on which these adjustments become effective. Amongst other things the Index Calculation Agent can consider adjustments executed by an exchange as a result of the corporate action concerning options and futures.

Splits require the recalculation of the "W" parameter if the split ratio is applicable to the price change, as follows:

$$W_{i,t+1} = W_{i,t} * S$$

Whereas:

$W_{i,t+1}$ is the number of units / notional affected in the Index at time t+1

W_{ti} is the number of units / notional affected in the Index at time t

S Units / notional after the split for every unit / notional before split

Share distributions require the recalculation of the "W" parameter if the distribution ratio is applicable to the price change, as follows:

$$W_{i,t+1} = W_{i,t} * (1 + S)$$

Whereas:

$W_{i,t+1}$ is the number of units / notional affected in the Index at time t+1

W_{ti} is the number of units / notional affected in the Index at time t

S Units / notional for every unit / notional before distribution

3.5 Rebalancing and Allocation Advice

The Index is rebalanced monthly within the period of the first three (3) Business Days of each calendar month (the "**Rebalancing Period**"). The Index Allocator shall provide Allocation Advice to the Index Administrator, if any, only on the first Business Day of the Rebalancing Period (each an "**Instruction Date**").

The Index Administrator may disregard any Allocation Advice provided to it on any day other than an Instruction Date.

"**Allocation Advice**" means any advice given by the Index Allocator to the Index Administrator (i) relating to an increase or reduction in any Index Component's weighting, including the timeframe of planned execution (phase-in/phase-out allocation) (the "**Allocation Implementation Period**") by

providing the exact change in weighting on each Business Day for each Index Component within the Allocation Implementation Period, provided that the Allocation Implementation Period may not exceed three (3) Business Days; (ii) the removal of any Index Component from the Index; (iii) the addition of any instrument that satisfies the Index Component Selection Criteria (such instrument an "**Eligible Component**"), in each case provided that such advice is in line with the Index Objective and the economics of the Reference Market as determined by the Index Administrator.

The Index Administrator will implement validly given Allocation Advice in a timely manner following its receipt by reducing or increasing the number of units / notional of each Index Component or, as the case may be, by adding the Eligible Component and increasing the relevant number of units / notional of such component, in each case using their Official Valuation applicable to such Index Valuation Date and in over the applicable Allocation Implementation Period, in each case as mentioned in the Allocation Advice.

3.6 Data Provider

Each Allocation Advice is considered input data and the Index Allocator therefore acts as Data Provider in accordance with the Benchmarks Regulation. Other relevant input data, i.e. data used when determining any Official Valuation, will be sourced from publicly available sources (readily available data) to maintain or calculate the Index.

3.7 Index Continuity and Market Disruption

In case of missing, insufficient, inaccurate or unreliable input data or non-compliance with the standards as set out below, for any of the required data to calculate the Index, the Index Administrator may not calculate and publish the Index. The decision will be taken at the Index Administrator's sole discretion.

In case the minimum requirements and standards set out below are not fulfilled for a considerable time, the Index Administrator, to protect users of the Index, will publish such circumstance either by amending the Index Guidelines, or by notice on its website. Where appropriate, the Index Administrator will consult experts to make the decision.

The minimum requirements for the quantity of input data are:

- A price for each Index Component must be available; and
- a weight of each Index Component must be available or calculatable.

The minimum standards for the quality of input data are:

- Data must be reliable and consistent;
- data must be robust; and
- data must be verifiable.

3.8 Internal Review and Approval of Methodology

After the preparation of the index related documentation, a review round with regards to whether the requirements of the Benchmarks Regulation are reflected and whether there is an operational feasibility for implementation takes place. Thereafter, a revision and further coordination with relevant parties takes place, including a dedicated checklist maintained by the Index Administrator to ensure compliance with the Benchmarks Regulation. Such a checklist includes, among other things, documentation requirements of the Benchmarks Regulation. After the relevant steps have been successfully completed, the management of the Index Administrator has discretion to approve launching an index. The methodology is reviewed annually.

3.9 Consulting Procedures and Significant Change

In the event of a proposed Significant Change in the Index methodology, it is the responsibility of a relevant party to contact the Index Administrator and notify the relevant request. Such notification must in any case be made in writing or by email. The Index Administrator will subsequently review the case regarding the reasons given.

For the purposes of this section 3.9 "**Significant Change**" means, in each case determined in the Index Administrator's reasonable discretion taking into account the Index Sponsor's interests and Index users at all times:

(i) Any change which, at the time of the conversion, lead to a change in the Index Value of more than 3% compared to the Index Value prevailing in the absence of such change on the last Index Valuation Day prior to such change; and

(ii) any methodological adjustment that leads to significant changes of the Index Values in the longer term.

In case of a Significant Change, the Index Administrator will provide updated Index Guidelines on its website. In addition, any licensees will be informed by the Index Administrator about any Significant Change.

4 CHANGE HISTORY

11.09.2020 – 1.0. – Initial version

5 CONTACT DATA

Information regarding the Index

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Germany

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E-Mail: info@lixxinnovation.com
Website: www.lixxinnovation.com

6 DEFINITIONS

Allocation Advice	Has the meaning given to such term in section 3.5 (*Rebalancing and Allocation Advice*).
Annex	Means an annex to these Index Guidelines, each of which form an integral part of these Index Guidelines.
Business Day	Any day on which there is neither a Zurich, Switzerland, public holiday nor a Düsseldorf, Germany, public holiday.
Benchmarks Regulation	Means Regulation (EU) 2016/2011 of the European Parliament and the Council of 8 June 2016 as amended.
Change in Law	Any change in any national or international laws, regulations, directives, decisions by courts of last resort or administration practice applicable to any Index Component and affecting any Index Component to the economic detriment of the Index Administrator or any holder of any Index Component.
Data Provider	A contributor of data to maintain or calculate the Index in accordance with Article 11 of the Benchmarks Regulation.
Index	OpenMetrics-JIMAG EUR Bonds & Precious Metals Optimized Index
Index Administrator	LIXX
Index Allocator	Jacot Investment Management AG, a stock corporation (*Aktiengesellschaft)* under Swiss law, registered with the commercial register (*Handelsregister*) under CHE-447.025.363 and having its principal place of business at Dufourstrasse 47, 8008 Zurich, Switzerland. Under the Index Sponsor & Allocation Agreement between Jacot Investment Management AG and LIXX GmbH, the Index Allocator has the right to appoint a sub-allocator and intends to appoint OpenMetrics LLC, Dufourstrasse 47, 8008 Zurich, Switzerland, as sub-allocator as of the Index Start Date.
Index Calculation Agent	LIXX
Index Component	Any constituent of the Index.
Index Component Selection Criteria	Has the meaning given to such term in **Annex 2**.

Index Objective	Has the meaning given to such term in section 1.1 (*Summary of Index Specifications*).
Index Sponsor	Jacot Investment Management AG, a stock corporation (*Aktiengesellschaft)* under Swiss law, registered with the commercial register (*Handelsregister*) under CHE-447.025.363 and having its principal place of business at Dufourstrasse 47, 8008 Zurich, Switzerland.
Index Start Date	Has the meaning given to such term in section 1.3 (*Index Start Date and Initial Index Value*).
Index Valuation Date	Has the meaning given to such term in section 1.5 (*Prices and Calculation Frequency*).
Index Value	Value of the Index on the Index Valuation Date.
Initial Index Value	Has the meaning given to such term in section 1.3 (*Index Start Date and Initial Index Value*).
LIXX	LIXX GmbH, a limited liability company (*Gesellschaft mit beschränkter Haftung*) under German law, registered with the commercial register (*Handelsregister*) of the local court (*Amtsgericht*) of Düsseldorf under HRB 81816 and principal place of business at Fürstenwall 172a, 40217 Düsseldorf, Germany.
Official Valuation	The official valuation is based on publicly available data, that has been made available by internationally established information services or exchanges. Such data will include daily end of day closing values of each Index Component, as they are available one Business Day prior to the relevant Index Valuation Day. If no data is available on the relevant valuation day, the last available closing value is used.
Rebalancing Period	Has the meaning given to such term in section 3.5 (*Rebalancing and Allocation Advice*).
Reference Market	Has the meaning given to such term in section 1.1 (*Summary of Index Specifications*).
Regulatory Event	Any public or private statement or action by, or response of, any competent authority or any official or representative of any competent authority acting in an official capacity affecting any Index Component to the economic detriment of the Index Administrator or any holder of any Index Component.

Tax Event	Means any any change in the tax treatment of a holder of Index Components which is based on either a change in legislation or a change in tax administration practice.
Total Return Net Index	Index calculated based on reinvested dividend or coupon payments, reduced by any Withholding Tax.
Universe of Index Components	Means the instruments described in **Annex 1**.
Withholding Tax	Means 35%.

ANNEX 1: UNIVERSE OF INDEX COMPONENTS

Shares in exchange traded funds (ETF) relating to the Reference Market.

ANNEX 2: INDEX COMPONENT SELECTION CRITERIA

Each instrument selected from the Universe of Index Components must fulfil the following criteria to be eligible for inclusion in the Index. The relevant instrument must:

(i) Have a price that is set regularly and publicly accessible;

(ii) be denominated in EUR or CHF;

(iii) have assets under management (AUM) at the time of inclusion in the Index in excess of 10 million EUR; and

(iv) be similar in the investment theme (e.g. cannot replace MSCI World with MSCI Germany)

(the "**Index Component Selection Criteria**").

The Index Component Selection Criteria are required to be fulfilled at the time of inclusion of the relevant instrument as Index Component in the Index. However, fulfilment of the Index Component Selection Criteria will not be monitored on an ongoing basis following such inclusion.

ANNEX 3: ALLOCATION MECHANISM

The information included in this **Annex 3** has been provided by the Index Allocator, who is solely responsible for its content.

Step 1: BCP Analysis

The Index dynamically allocates – using a rule-based methodology (the "Model") between three exchange-traded funds with exposure to European Government bond market, three exchange-trade funds with exposure to the European Corporate bond market (each an Fixed Income Instrument), and four exchange-traded funds with exposure to precious metals (Commodity Instrument) using variance-weighted trend indicators adjusted for regime shifts as further explained herein. Together, these are referred to as the Investment Instruments. The Index aims to provide an improved risk/return profile compared to a passive investment in the Fixed Income Instruments and protect against major drawdowns during severe market crises.

The conceptual Model to allocate weights builds on the assumption that an Investment Instrument can undergo sudden changes (regime shifts) in its price dynamic. A regime shift occurs if new price information of an Investment Instrument cannot be explained with the dynamics of its older price information i.e. a change in the expected trend and/or a change in expected variance.

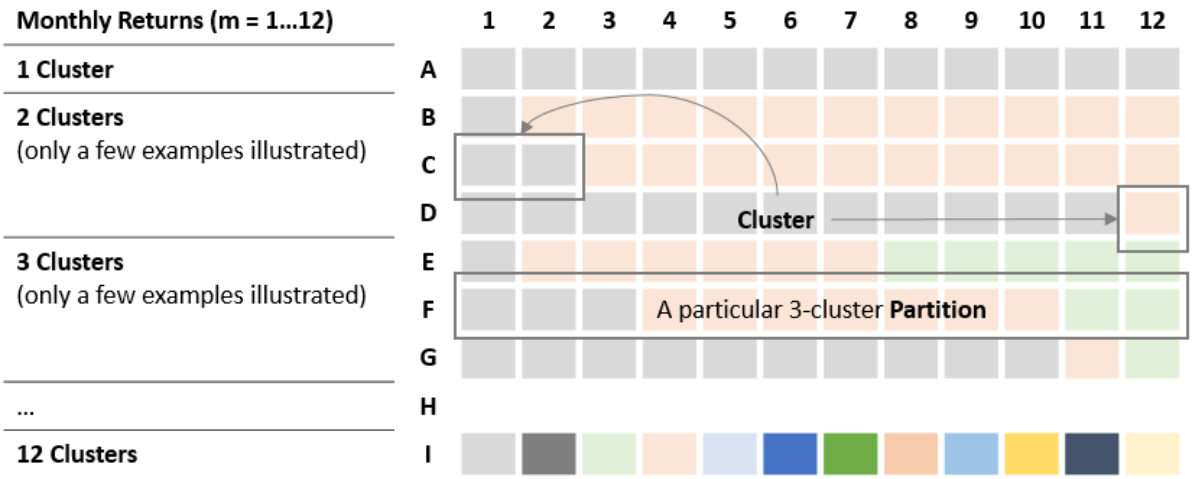
The Model considers the last 12 monthly returns of an Investment Instrument. In order to avoid an arbitrary partitioning of the dataset, the Model takes into consideration any possible partitioning of the 12 monthly returns of an Investment Instrument (see Figure 1). For each cluster in a partition, the Model calculates the expected trend and expected variance as well as the likelihood of the partition itself (i.e. the probability that the partition describes the dataset accurately)[1].

Figure 1 illustrates a few examples only – e.g. there are exactly 11 possible partitions with two clusters and the Model returns 22 expected trends (11 partitions × 2 clusters), 22 expected variances and 11 likelihoods for those 11 partitions.

Once all the expected trends, expected variances and likelihoods have been computed, the Model calculates – for each of the 12 monthly returns used – the final trends ($\mathbf{T}_m$), the final variances ($\mathbf{V}_m$) and, using the likelihoods of partitions, the so called change point probabilities ($\mathbf{P}_m$) i.e. 36 values in total (3 statistics T_m, V_m, P_m × 12 monthly returns, see Figure 2).

[1] The Model uses **expected** trends and **expected** variances instead of sample trends (means) and variances. Analytical solutions based on Bayesian inference for the expected trend, expected variance and the likelihood are illustrated in the Thesis.

Figure 1: Partitioning of Monthly Returns

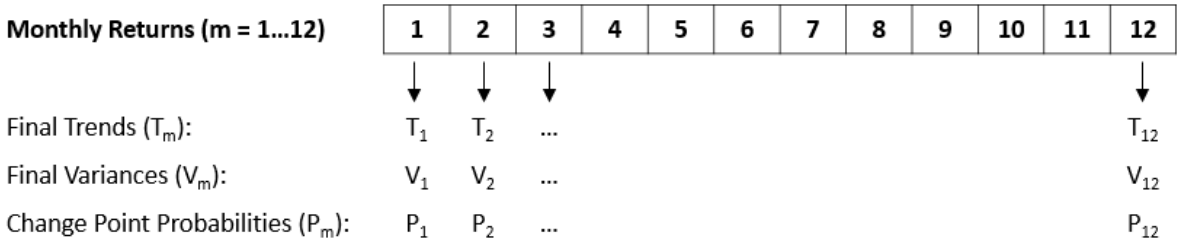


Source: OpenMetrics Solutions LLC. For the avoidance of doubt, a cluster can only contain connected monthly returns e.g. it is impossible to have a cluster containing monthly return 1 and monthly return 12).

In order to calculate T_1 (final trend for monthly return 1), the Model sums the expected trends from all clusters containing monthly return 1 weighted by the likelihood of the corresponding partition containing the relevant cluster. The Model does the same calculations for T_2 to T_{12}. V_m is calculated in a similar fashion but instead of using the expected trends, the Model uses the expected variances instead.

The change point probabilities (P_m) indicate the likelihood of a regime shift between monthly return m-1 and m. Ignoring P_1, in order to calculate P_2 (change point probability between monthly return 1 and 2), the Model sums the likelihood of the partitions where the partition has a cluster starting with monthly return 2. For the examples in Figure 1, the Model would only consider rows B, E and I. P_3 to P_{12} are calculated in the same way. P_1 is assumed to be zero. Since it is not possible to make a statement about a change point between return 0 and 1 (the Model does not know monthly return 0).

Figure 2: Final Trends, Variances and Change Point Probabilities



Source: OpenMetrics Solutions LLC.

So far, only one Investment Instrument was considered, but the 36 statistics in Figure 2 are computed for each of the ten Investment Instruments. $T_{m,j}$, $V_{m,j}$ and $P_{m,j}$ to indicate the final trends, variances and change point probabilities of month m and Investment Instrument j are used.

Step 2: Estimation of the BCP Mean and Variance

At a given point in time t and for a given Investment Instrument k, the results of the BCP analysis for the past 12 months are calculated:

$$\vec{r}_{t,k} = \{r_1, r_2, \dots, r_s\}$$
$$\vec{m}_{t,k} = \{m_1, m_2, \dots, m_s\}$$
$$\vec{v}_{t,k} = \{v_1, v_2, \dots, v_s\}$$
$$\vec{p}_{t,k} = \{p_1, p_2, \dots, p_s\}$$

where $\vec{r}_{t,k}$ are the returns of asset k at time t, $\vec{m}_{t,k}$ are the posterior means of Investment Instrument k at time t, $\vec{v}_{t,k}$ are the posterior variances of Investment Instrument k at time t and $\vec{p}_{t,k}$ are the posterior probabilities of Investment Instrument k at time t. Note that the posterior probabilities are bounded between 0 and 1.

For every point in time within the lookback window there is an estimation for the (posterior) mean, the (posterior) variance and the (posterior) probability. At any point in time the posterior probabilities describe the probability that there is a structural break within the random dynamic that is generating the returns.

To arrive at the monthly allocation, only one estimation of the mean and the standard deviation is required for the portfolio at time t. For this, the structural break index (SBX) is calculated which is based on the posterior probabilities:

$$\vec{w} = \{w_1, w_2, \dots, w_s\}$$
$$w_i = \frac{i-1}{s-1}$$
$$SBX_t = max\left(\vec{p}_{t,k} \cdot \vec{w}\right)$$

The posterior probabilities are weighted over time. The more recent they are the more weight they get. From the time weighted probabilities, the maximum defines the SBX. It means that if a structural break shows up initially, it is taken fully into account. As the structural break gets older it will be considered less and less.

The final estimation of the mean and the standard deviation at time t for asset k is calculated using an exponential moving average (EMA):

$$EMA_\lambda(\vec{x}) = \sum_{i=1}^{s} \lambda(1-\lambda)^{s-t} x_i + (1-\lambda)^s \bar{x}$$
$$\hat{\mu}_{t,k} = EMA_\lambda\left(\vec{m}_{t,k}\right)$$

$$\hat{\sigma}_{t,k} = \sqrt{EMA_{\lambda}(\vec{v}_{t,k})}$$

$$\lambda = SBX \cdot c$$

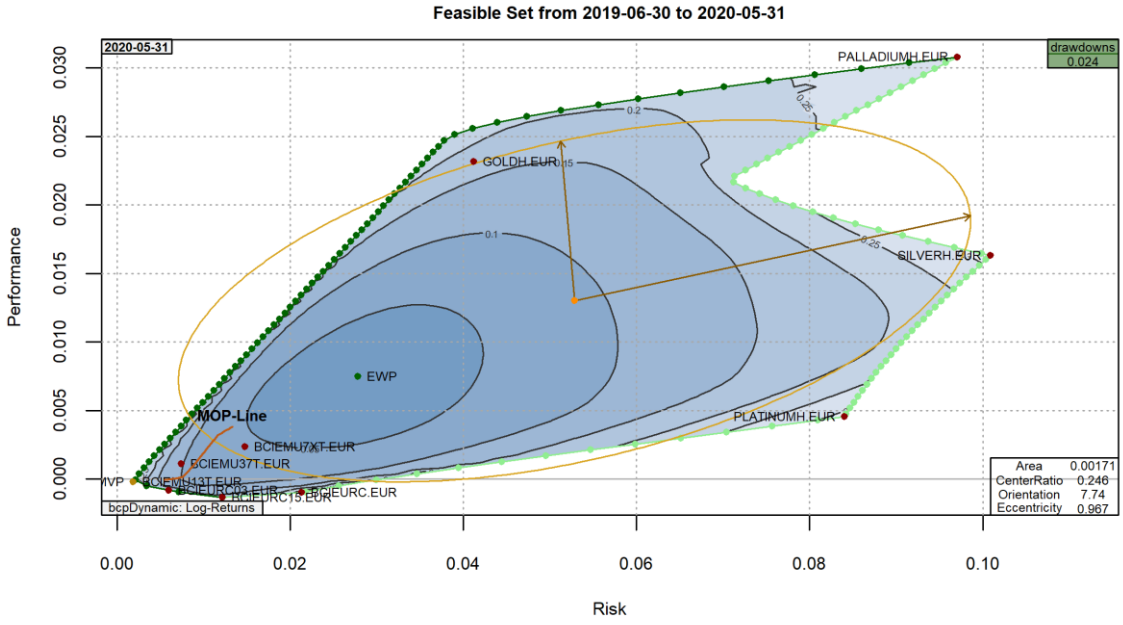
where $\bar{x}$ is the mean of the samples $\vec{x}$ and $0 \leq \lambda \leq c$ controls to which extend newer samples are favoured towards older observations. The higher λ, the more the newer samples are favoured. $\hat{\mu}_{t,k}$ is the estimation of the mean at time t for asset k and $\hat{\sigma}_{t,k}$ is the estimation of the standard deviation at time t for asset k.

The constant c for this index is set to a value of 0.2. This means that for an SBX value of 1, approximately 50% of the weight is on the newest 25% of the data; and that the newest data point has approximately 9 times more weight than the oldest data point.

Using this approach makes sure that newer observations (returns) become more weight in the final estimations of the trend and the risk if there are indications for a change in dynamic (a high value of the SBX).

Step 3: Orientation of the Feasible Set

In the picture below the feasible set is defined through the (blue) shaded area for the 12 month period up to the end of May 2020. The shaded area is showing the diversification level of a specific portfolio in the feasible set. The portfolio with the highest diversification is the equal weights portfolio (EWP). Generally, all portfolios on the efficient frontier are highly concentrated and do therefore show a low level of diversification.



The efficient frontier goes from the minimum variance portfolio (MVP) towards the Investment Instrument with the highest return (PALLADIUMH.EUR). It is part of the minimum variance locus which goes clockwise from the Investment Instrument with the lowest return (BCIEURC15.EUR) to the Investment Instrument with the highest return. The maximum variance locus goes counter clockwise from the Investment Instrument with the lowest return to the Investment Instrument with the highest return. Together the minimum variance locus and the maximum variance locus define the hull of the feasible set.

Thus, the feasible set of an investment universe can be described as a picture through the pixels inside the hull of the feasible set. This allows to calculate various moments of the feasible set. Based on these moments the geometric shape factors (GSF) can be calculated. The area (invariant under translation and rotation), the centre (invariant under scale and rotation), the orientation (invariant under translation and scale) and the eccentricity (invariant under translation, scale, and rotation) of the feasible set. Which are also the parameters needed to draw an ellipse which can serve as an approximation of the feasible set. Note that the GSF can also be calculated directly from the hull, as shown in step 5.

For this Index only the orientation of the feasible set is used: It describes the direction of the risk premium. If the direction is positive taking more risk would generally be compensated with more performance.

Step 4: Calculation of the Hull of the Feasible Set

To calculate the hull of the feasible set at time *t* the quadratic optimization problem as defined below is solved repeatedly for different target returns $\vec{r}_{target} = \{r_{target,1}, r_{target,2}, \dots, r_{target,m}\}$:

$$\min_{\vec{w}} \quad \pm\vec{w}'\Sigma\vec{w}$$

$$\text{s.t.}$$

$$\vec{1}'\vec{w} = 1$$

$$\vec{\mu}'\vec{w} = r_{target,i}$$

$$0 \leq w_i \leq 1$$

The sequence of equally spaced target returns $\vec{r}_{target}$ goes from the minimum of the expected returns $r_{target,1} = min(\vec{\mu})$ to the maximum of the expected returns $r_{target,m} = max(\vec{\mu})$. The more target returns (m) that are chosen between the minimum and the maximum the higher the resolution of the hull. We have chosen m to be 75. To calculate the minimum variance locus $+\vec{w}'\Sigma\vec{w}$ is used and to calculate the maximum variance locus $-\vec{w}'\Sigma\vec{w}$ is used.

Note that the weights are restricted such that they have to be between 0 and 1 (long only) and sum up to one (fully invested). This represents a natural and straightforward investment style. Many investors

do or cannot deviate from these restrictions. Since this problem cannot be solved analytically anymore for more than two Investment Instruments it must be solved numerically. There are various open source or commercial solvers to achieve this.

The solution will be a portfolio defined through the weights ($\vec{w}$) that minimize the objective function while respecting the constraints. The portfolio will have a return of $r_p = \vec{\mu}'\vec{w} = r_{target,i}$ and a variance of $\sigma_p^2 = \vec{w}'\Sigma\vec{w}$ where the variance is the lowest or highest possible variance for that return. Every portfolio can be visualized through its expected return r_p (performance) and the standard deviation σ_p (risk) within the risk-performance-plane which leads to the hull of the feasible set (see picture at the beginning of step 3). Randomly choosing weights between zero and one such that they sum up to one will always lead to a portfolio that lies inside the feasible set.

To calculate the hull of the feasible set the estimations of the means ($\vec{\mu}$) and the standard deviations ($\vec{\sigma}$) at time t for all Investment Instruments within the investment universe are needed. How these estimations are derived using a BCP analysis is explained in step 2. Using the standard deviations and an estimation of the correlation matrix, the covariance matrix Σ can be calculated:

$$\mu_i = \hat{\mu}_{t,k} = EMA_\lambda(\vec{m}_{t,k}), \quad \sigma_i = \hat{\sigma}_{t,k} = \sqrt{EMA_\lambda(\vec{v}_{t,k})}$$

$$\Sigma_{i,j} = \sigma_{i,j} = \sigma_i \cdot \sigma_j \cdot \rho_{i,j}$$

where $\rho_{i,j} = \hat{\rho}(\vec{r}_{t,i}, \vec{r}_{t,j})$ is an estimation of the correlation between the returns of Investment Instrument i at time t ($\vec{r}_{t,i}$) and the returns of Investment Instrument j at time t ($\vec{r}_{t,j}$). Pearson's sample correlation estimation is used.

As already pointed out, the maximum variance locus can be found by minimizing $-\vec{w}'\Sigma\vec{w}$. But since that part of the hull is concave, many optimizers struggle to find the minimum. On the other hand, the maximum variance locus does always consist of only two Investment Instruments and can therefore be calculated analytically. For that the minimization problem defined at the beginning of this chapter has to be solved for two Investment Instruments. This can be done by solving the equation system of the constraints as:

$$w_1 = \frac{r_{target,i} - \mu_2}{\mu_1 - \mu_2}$$

$$w_2 = 1 - w_1$$

$$\sigma_p = [w_1 \;\; w_2] \begin{bmatrix} \sigma_{1,1} & \sigma_{1,2} \\ \sigma_{2,1} & \sigma_{2,2} \end{bmatrix} \begin{bmatrix} w_1 \\ w_2 \end{bmatrix}$$

$$r_p = r_{target,i}$$

where r_p is the return and σ_p the variance of the pairwise portfolio that has weights $\vec{w} = \{w_1, w_2\}$. After calculating the efficient frontiers of all pairwise portfolios the maximum variance locus consists of the

pairwise portfolios that have the highest variance given the target return $r_{target,i}$. To capture the edges of the maximum variance locus the target return vector $\vec{r}_{target}$ has been extended with the estimations of the means $\vec{\mu}$.

The pairwise approach is actually the algorithm we are using to calculate the maximum variance locus. From a numerical point of view, it is completely reliable (in contrast to the optimization approach which struggles with the concave nature of the problem) and much faster than the optimization approach.

The calculation of the hull of the feasible set can be summarized as follows:

1. Define a target return vector for the minimum variance locus: $\vec{r}_{target,min}$.
2. For every target return calculate the portfolio with the lowest variance (using the optimization approach). Calculate the standard deviation for that portfolio. The result will be a vector of these standard deviations that has the same length as the target return vector: $\vec{s}_{target,min}$.
3. Define a target return vector for the minimum variance locus: $\vec{r}_{target,max}$.
4. For every target return calculate the portfolio with the highest variance (using the pair-wise approach). Calculate the standard deviation for that portfolio. The result will be a vector of these standard deviations that has the same length as the target return vector: $\vec{s}_{target,max}$.

Step 5: Calculation of the Orientation of the Feasible Set

The coordinates of the hull of the feasible set describe a polygon:

$$P = [\vec{x}, \vec{y}]$$

where $\vec{x}$ holds the target return vectors ($\vec{r}_{target,min}$ and $\vec{r}_{target,max}$) and $\vec{y}$ holds the standard deviations for the minimum variance locus and the maximum variance locus ($\vec{s}_{target,min}$ and $\vec{s}_{target,max}$). From these coordinates the orientation of the feasible set can be calculated directly through a principal component analysis (PCA):

$$\Sigma_{hull} = \begin{bmatrix} var(\vec{x}) & cov(\vec{x}, \vec{y}) \\ cov(\vec{x}, \vec{y}) & var(\vec{y}) \end{bmatrix}$$

$$\theta = arctan\frac{e_2}{e_1}$$

where θ is the orientation of the feasible set and $\vec{e} = [e_1, e_2]$ is the eigenvector of the biggest eigenvalue of Σ_{hull}. Not that the orientation is in radian. It can easily be transformed into degrees: $(\theta \cdot 360)/(2 \cdot \pi)$.

Step 6: Portfolio Weights

In the final step, the BCP estimation of the covariance matrix Σ (see step 4) is used to calculate the portfolio weights through optimization using a multi objective function. The orientation (θ) is used to

dynamically position the portfolio on the feasible set. For that we solve the following optimization problem:

$$\min_{\vec{w}} \lambda_p \cdot var(\vec{w}) + (1 - \lambda_p) \cdot \vec{w}' \Sigma \vec{w}$$

$$s.t.$$

$$\vec{1}' \vec{w} = 1$$

$$0 \leq w_i \leq 1$$

where λ_p should not be smaller than *0* or larger than *1*. If λ_p is *0*, the result of the optimization problem above would be the global minimum variance portfolio (MVP). If λ_p is *1*, the result of the optimization problem above would be the globally best diversified portfolio, which is the equal weights portfolio (EWP). For all other values of λ_p the resulting portfolio would lie between the MVP and the EWP.

λ_p lies between *0.002* and *0.05,* by construction. If the orientation of θ is given in degrees, then λ_p is calculated as follows:

$$\lambda_p = max\left(0, \frac{\theta}{90}\right) \cdot (0.05 - 0.002) + 0.002$$

Dividing θ by 90 results in values between -1 and 1. Taking the maximum of that value and *0* means that if the orientation goes towards *0*, the target portfolio will more and more become the minimum variance portfolio (MVP). It does also stay at the MVP if the orientation gets negative, since for negative orientations the equal weights portfolio (EWP) would generally have a lower return and a higher risk than the MVP. Finally, the value which is now between *0* and *1* gets linearly scaled into the range from *0.002* (lower bound if the orientation goes towards *0* degrees) to *0.05* (upper bound if the orientation goes towards *90* degrees).

The lower bound ensures that there is always a minimum amount of diversification since the portfolios on the efficient frontier (e.g. the MVP) are often highly concentrated. The upper bound was introduced since the impact of lambda within the multi objective function is not linear. It means that a value of 0.05 is not only 5% on the way from the MVP to the EWP; but can go up to 80% towards the EWP.

The picture at the beginning of step 3 shows the orientation and the MOP-Line of the feasible set for the 31.05.2020. The beginning of the MOP-Line shows the portfolio if λ_p would have a value of *0.002* and the end of the MOP-Line shows the portfolio if λ_p would have a value of *0.05* (which is about 50% towards the EWP for this case). For any value of λ_p between *0.002* and *0.05* the portfolio would lie on the MOP-Line.

Of course, the upper bound (*0.05*) could be chosen higher to get more exposure into the precious metals. The reason for this rather conservative value is that the portfolio is also intended for rather conservative

investors (risk-wise). The goal is to get a boost in performance if the risk-premium is given. The larger that boost is designed, the more risk has to be taken, which would lead to more volatility and larger drawdowns.

ANNEX 4: INITIAL INDEX ALLOCATION

The initial weight allocation for the Index Components is set out below.

ISIN	Index Component Name	Weight
IE00B3VTMJ91	iShares EUR Govt Bond 1-3yr UCITS ETF EUR Acc	23.55%
IE00B3VTML14	iShares EUR Govt Bond 3-7yr UCITS ETF ACC	19.45%
IE00B3VTN290	iShares EUR Govt Bond 7-10yr UCITS ETF EUR Acc	14.16%
IE00BC7GZW19	SPDR Bloomberg Barclays 0-3 Year Euro Corporate Bond UCITS ETF	20.53%
IE00B4L60045	iShares EUR Corp Bond 1-5yr UCITS ETF	15.36%
IE00B3F81R35	iShares Core EUR Corp Bond UCITS ETF	6.58%
CH0103326762	ZKB Gold ETF	0.21%
CH0183136040	ZKB Silver ETF	0.00%
CH0106407213	Swisscanto ETF Precious Metal Physical Palladium	0.16%
CH0106406231	Swisscanto ETF Precious Metal Physical Platinum	0.00%