Madeira Wine Index

Rare Wine Indices

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Contents

1 Introduction and Objective

1.1 Introduction

The Madeira Wine Index ("the Index") is designed to be a transparent, rules-based benchmark for tracking the price performance of vintage and solera madeira wines from a select group of established producers. The Index provides a representative measure of the secondary market value of Madeira wine, based on transaction data from auctions.

This document details the governing rules, constituent eligibility criteria, calculation methodology, and maintenance policies of the Index. It serves as the guide for all aspects of the Index's construction and management.

1.2 Objective

The primary objective of the Index is to provide wine investors, collectors, and enthusiasts with a reliable and consistent benchmark for the price evolution of a specific segment of the fine wine market. The Index aims to reflect the real-world transaction values of these wines, thereby creating market transparency and providing a tool for performance measurement and academic research.

2 Governance and Disclaimer

2.1 Index Administrator

The Index is calculated and administered by the Index Administrator (Rare Wine Indices). The Index Administrator is responsible for overseeing the methodology and ensuring its consistent application. The Index Administrator is responsible for the review of the methodology, market conditions, and potential changes. Any modifications to this methodology will be listed in a log below.

2.2 Data Provider

The data provider for the Index is Wine Labs. Pricing data used in the calculation of the Index is sourced directly from Wine Labs, a fine wine price intelligence platform. Visit www.winelabs.com to learn more.

2.3 Disclaimer

This document is for informational purposes only. The Index Administrator makes no representation or warranty, express or implied, as to the accuracy or completeness of the information contained herein. The Index Administrator is not liable for any errors, omissions, or interruptions in the calculation or dissemination of the Index. The Index is not intended to be, and should not be construed as, investment advice. Inclusion of a wine in the Index does not constitute a recommendation to buy, sell, or hold that wine.

3 Index Universe and Eligibility Criteria

3.1 Eligible Producers

The Index Universe is restricted to wines from the following eight (8) madeira producers:

- Blandy's
- d'Oliveiras
- Barbeito
- Cossart & Gordon
- Justino's
- Leacock
- Henriques & Henriques
- H. M. Borges

3.2 Eligible Wine Types

To be eligible for inclusion in the Index calculation, a wine must meet the following criteria:

1. **Vintage Designation:** The wine must be a "Vintage" or "Solera" wine with a specific vintage year stated.
2. **Exclusions:** All "Non-Vintage" (NV) wines, which are blended from multiple years without a stated vintage, are explicitly excluded from the Index Universe.

3.3 Bottle Size Requirements

Only transactions involving standard 750ml (75cl) bottles are included. Data from other bottle formats (e.g., 375ml, 1.5L) are excluded unless a reliable volume adjustment can be applied.

3.4 Universe Review

The Index Administrator reviews the list of eligible producers and wine types annually to ensure they remain representative of the madeira market. Any changes to the universe criteria will be documented here.

4 Data Sources and Pricing

4.1 Price Definition

The price used for each transaction in the Index calculation is the final auction price, which is defined as the auction "hammer price" plus any applicable buyer's premium. This "all-in" price reflects the total cost to the purchaser but generally excludes applicable taxes, shipping cost and storage fees. All prices are converted to a single base currency before being used in the calculation.

4.2 Data Validation and Refinement

To the extent possible, the data received from the provider is subject to a cleansing process to identify and correct potential errors. This includes checks for data consistency.

5 Index Calculation and Methodology

5.1 Overview - RSR

The Index is calculated using a **Repeat Sales Regression (RSR)** methodology. The calculation is performed on a quarterly basis using weighted least squares (WLS) following the Case-Shiller methodology.

5.2 Repeat Sales Requirement

Only wines that have been observed trading at least twice in the dataset are included in the RSR calculation.

For a wine with unique identifier w, let P_{w,t_1} and P_{w,t_2} denote the prices at which it traded in quarters t_1 and t_2, where $t_1 < t_2$. The log price change is:

$$y_w = \ln(P_{w,t_2}) - \ln(P_{w,t_1})$$

5.3 Design Matrix Construction

The RSR methodology uses a design matrix $\mathbf{X}$ based on the Bailey-Muth-Nourse approach. Let T denote the number of time periods (quarters) in the dataset, and let the base period be the first quarter.

For each repeat-sales pair, we construct a row in the design matrix with $T-1$ columns (excluding the base period):

- A value of -1 in the column corresponding to the sale period t_1
- A value of $+1$ in the column corresponding to the purchase period t_2
- Zeros in all other columns

If n is the number of repeat-sales pairs, then $\mathbf{X}$ is an $n \times (T-1)$ matrix, and $\mathbf{y}$ is an $n \times 1$ vector of log price differences.

5.4 Two-Stage Weighted Least Squares (WLS) Estimation

Following Case-Shiller (1987), we employ a two-stage WLS procedure to account for heteroskedasticity in the residuals:

Stage 1: Ordinary Least Squares (OLS)

We first estimate the coefficient vector $\boldsymbol{\beta}_{\text{OLS}}$ by solving:

$$\boldsymbol{\beta}_{\text{OLS}} = (\mathbf{X}^\top \mathbf{X})^{-1} \mathbf{X}^\top \mathbf{y}$$

The residuals are computed as:

$$\mathbf{e} = \mathbf{y} - \mathbf{X}\boldsymbol{\beta}_{\text{OLS}}$$

Stage 2: Modeling Heteroskedasticity
The squared residuals e_i^2 are modeled as a function of the time gap $g_i = t_2 - t_1$ between sales:

$$e_i^2 = a + b \cdot g_i + c \cdot g_i^2 + \epsilon_i$$

where a, b, c are estimated using OLS on the auxiliary regression. The fitted values $\hat{\sigma}_i^2$ provide estimates of the variance for each observation. To ensure positivity, we floor the variance estimates at a small positive value (the 1st percentile or 10^{-8}).

Stage 3: Weighted Least Squares
Using the inverse of the estimated variances as weights $w_i = 1/\hat{\sigma}_i^2$, we re-estimate the coefficients:

$$\boldsymbol{\beta}_{\text{WLS}} = (\mathbf{X}^\top \mathbf{W} \mathbf{X})^{-1} \mathbf{X}^\top \mathbf{W} \mathbf{y}$$

where $\mathbf{W} = \text{diag}(w_1, \ldots, w_n)$ is the diagonal weight matrix.

5.5 Index Level Calculation

The estimated coefficients $\boldsymbol{\beta}_{\text{WLS}}$ represent the log price levels relative to the base period. To construct the index:

1. Set the base period (first quarter) coefficient to zero: $\beta_{\text{base}} = 0$
2. For all other periods $t = 1, 2, \ldots, T-1$, use the estimated coefficients β_t from the WLS regression
3. Convert to index levels by exponentiating and scaling to a base value of 1000:

$$I_t = 1000 \times \exp(\beta_t)$$

where $I_{\text{base}} = 1000$ by construction.

5.6 Kalman Filter

The index uses a **Kalman Filter** due to the illiquidity of the madeira market. This recursive algorithm provides an optimal estimate of the true underlying index value given a sequence of observed noisy measurements.

The Kalman Filter operates as a two-step process—prediction and update—based on a simple state-space model. Let x_t denote the true (latent) state of the index at time t, and z_t the observed noisy measurement. The model assumes:

$$x_t = x_{t-1} + w_t, \quad w_t \sim \mathcal{N}(0, Q)$$
$$z_t = x_t + v_t, \quad v_t \sim \mathcal{N}(0, R)$$

where:

- Q is the process variance, representing the uncertainty in the state evolution.

- R is the measurement variance, capturing the observation noise.

At each time step k, the algorithm performs the following recursive updates:
Prediction Step:

$$\hat{x}_{k|k-1} = \hat{x}_{k-1}$$

$$P_{k|k-1} = P_{k-1} + Q$$

Update Step:

$$K_k = \frac{P_{k|k-1}}{P_{k|k-1} + R}$$

$$\hat{x}_k = \hat{x}_{k|k-1} + K_k(z_k - \hat{x}_{k|k-1})$$

$$P_k = (1 - K_k)P_{k|k-1}$$

where:

- $\hat{x}_k$ is the filtered estimate of the true state at time k
- P_k is the posterior error covariance
- K_k is the Kalman Gain, weighting the measurement versus the prediction

The algorithm initializes with:

$$\hat{x}_0 = z_0, \quad P_0 = 1.0$$

In implementation, the filter iteratively estimates smoothed index values given a sequence of observed quarterly index levels z_t. The Index applies a process variance of $Q = 10^{-2}$ and a measurement variance of $R = 0.03$. The resulting series is the index.

5.7 Cumulative Returns

The cumulative return from the base period to quarter t is calculated as:

$$R_t = \frac{I_t - I_{\text{base}}}{I_{\text{base}}} = \frac{I_t}{1000} - 1$$

This represents the percentage gain or loss relative to the base quarter.

6 Index Publication and Maintenance

6.1 Base Date, Level and Chain-linking

The Index has an inception date of Q1 2001; thus, the first reported return is the change from Q1 to Q2 2001. Index levels reported subsequent to Q3 2025 utilize a chain-linking methodology. This approach permits the updating of index parameters while maintaining historical values at their previously published (frozen) levels to ensure time-series continuity. Starting base level:

$$I_{Q1,2001} = 1000$$

6.2 Calculation and Publication Frequency

The Index Level is calculated and published on a quarterly basis. The official Index value for a given quarter is calculated and published 14 business days following the end of that calendar quarter (e.g., the value for Q1, ending March 31st, will be published on the 14th business day of April).

6.3 Rounding and Precision

The final Index Level is rounded to two decimal places for publication. All intermediate calculations are performed with a higher degree of precision to minimize rounding errors.

6.4 Index History and Back-testing

Values including and prior to the Q3 2025 base date are considered back-tested simulations. This back-tested data is provided for analytical purposes and reflects the application of this methodology to historical data.

7 Other Technical Notes and Assumptions

7.1 Pairing Methodology

The index uses **adjacent pairs**, meaning that for a wine that trades multiple times, only consecutive transactions are paired (e.g., sale 1 to sale 2, sale 2 to sale 3).

7.2 Summary of Assumptions

The index relies on the following key assumptions:

- **Repeat-sales only:** Only wines with at least 2 observed trades are included
- **Time granularity:** Quarterly index using Auction Year and Auction Quarter
- **Constant quality:** Wine identity and bottle size (0.75L) are treated as constant quality
- **Currency:** All prices are assumed to be in the same currency (nominal, no CPI deflation)
- **Outlier treatment:** WLS reduces influence of long-gap pairs

8 Glossary of Terms

Hammer Price & Buyer's Premium The Hammer Price is the winning bid for a lot at an auction, excluding the buyer's premium. The Buyer's Premium is an additional charge on the hammer price of an item at auction, which is paid by the winning bidder.

Non-Vintage (NV) A wine that is a blend of grapes from multiple years, without a specific vintage date on the label. These are excluded from the Index.

Repeat Sales Regression (RSR) A statistical methodology that constructs price indices by tracking the same items as they trade multiple times over different periods. Widely used in real estate indices (e.g., Case-Shiller Home Price Index) and collectibles markets.

Solera A system of fractional blending used in aging wines, where a portion of the oldest cask is drawn for bottling, and the cask is then topped up with wine from the next oldest cask, and so on. A Solera wine in this Index must have a stated vintage year, which typically indicates the starting year of the Solera.

Vintage Wine A wine made from grapes that were primarily grown and harvested in a single specified year, which is stated on the label.

Weighted Least Squares (WLS) A regression technique that assigns different weights to observations based on their estimated variance, reducing the influence of less reliable data points. In the RSR context, pairs with longer time gaps receive lower weights.