

Does Rare Whisky Add Value in Multi-Asset Portfolios?

Lars Tegtmeier

Lars Tegtmeier

is a professor of financial management at the University of Applied Sciences in Merseburg, Germany.

lars.tegtmeier@hs-merseburg.de

KEY FINDINGS

- The driving factors of the price of rare whisky differ significantly from those of traditional and alternative assets, making rare whisky interesting as an investment.
- Owing to its specific risk-return characteristics, rare whisky qualifies as an independent asset class.
- The addition of rare whisky to an international multi-asset portfolio leads to statistically significant diversification benefits.

ABSTRACT

This article examines the importance of rare whisky as an alternative asset class, with particular attention given to its price driving factors, risk-return characteristics, and diversification potential. We show that rare whisky has specific characteristics in terms of the driving factors of its price that differ significantly from those of traditional financial assets, making rare whisky interesting as an investment. Furthermore, we analyze the risk-return characteristics of rare whisky in detail and compare them with those of stocks, bonds, hedge funds, private equity, commodities, real estate, and fine wines based on monthly data for the period from January 2013 to December 2020. The specific risk-return characteristics of rare whisky compared to the other asset classes under investigation suggest that rare whisky should be considered a separate asset class. Furthermore, it can be demonstrated that the addition of rare whisky to an international multi-asset portfolio leads to statistically significant performance improvements for various investment strategies.

Over the past decade, rare whisky has become an attractive asset class among both individual and institutional investors (Moroz and Pecchioli 2019). A key reason for this development is that rare whisky offers high expected returns combined with low volatility and low correlations to other asset classes. The low correlations of rare whisky returns with those of the returns of traditional and alternative asset classes result from its specific characteristics in terms of the driving factors of its price, which differ significantly from those of traditional and alternative assets. Unlike fine wine investments, where an extensive literature with a long history on fine wine return issues and the utility of fine wine investment for portfolio diversification exists, this is not the case for rare whisky. For example, the first empirical study of the returns on investments in fine wines was conducted more than 40 years ago by Krasker (1979). He was able to show that the returns on wine investments are no more profitable than those on a risk-free asset.

Since this seminal study, research in this area has been conducted by a variety of authors. Examples of recent research include the study of Bouri (2015), who

examined the dynamic conditional correlations between fine wine returns and stock market returns from the United States, the United Kingdom, Germany, France, and Japan. Using quantile correlations, Bouri found evidence that fine wines can hedge equity risk in the United States, the United Kingdom, Germany, and France. Aytac et al. (2016) investigated the relevance of wine investments for the diversification of French portfolios and found evidence that portfolios with wine are more efficient than those without. Nahmer (2020) examined the importance of fine wine as an alternative investment, with a particular focus on the cost of investing in fine wine. He showed that the inclusion of fine wine—at the index level—leads to only a slight improvement in annualized return and a significant increase in risk. Regarding costs, all portfolios containing fine wine show a lower Sharpe ratio. Finally, for a comprehensive literature review on fine wine returns, see Le Fur and Outreville (2019).

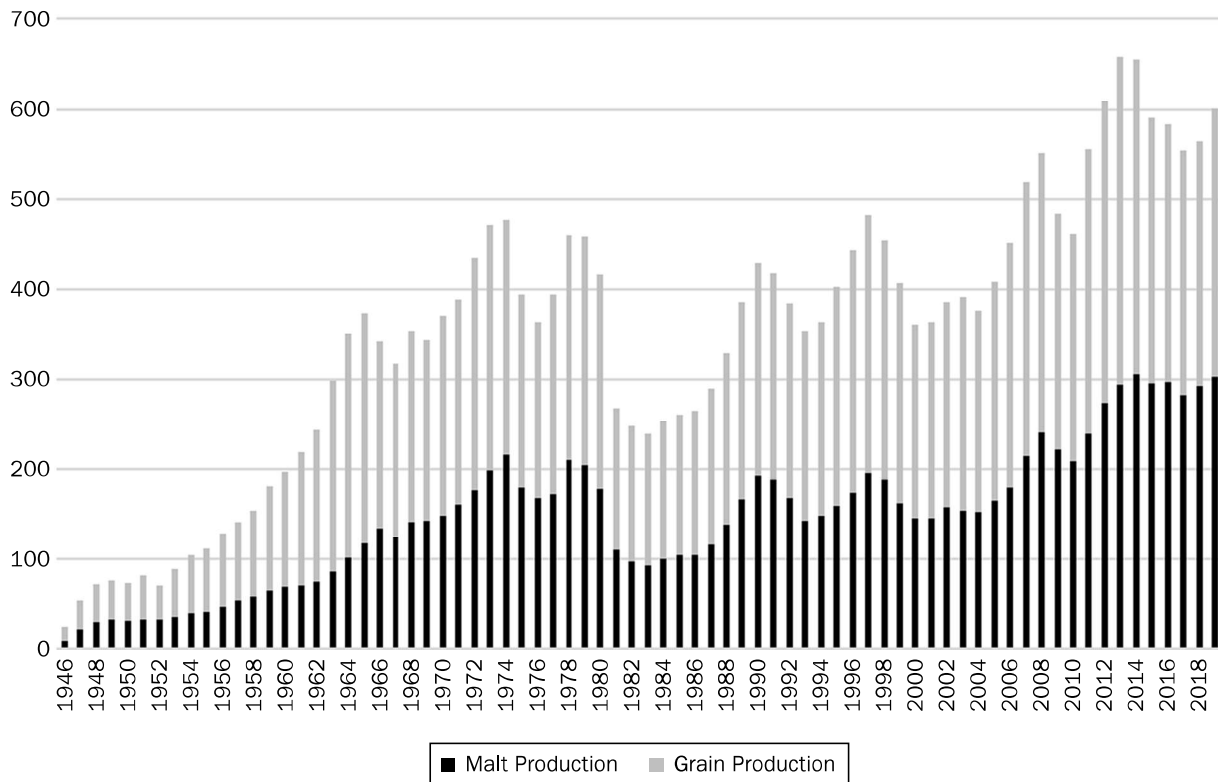
While extensive literature on wine as an investment exists, this is not the case for whisky. For whisky, there are only three studies that use hedonic price analysis to examine how whisky quality characteristics affect the level of whisky prices. Moroz and Pecchioli (2019) examined the main determinants of prices for single malt whiskies from Islay in Scotland. They were able to demonstrate that the vintage age and bottle age of whisky have the greatest influence on the whisky price, with vintage age having a stronger influence on price than bottle age. Furthermore, they were able to demonstrate that distillery reputation also has a significant impact on price. Moroz and Pecchioli (2021a) also examined the influence of ask and transaction prices on hedonic price estimates of vintage whiskies. They found evidence that whisky price estimates are independent of the prices used, that is, the ask or transaction prices used as dependent variables. Furthermore, Moroz and Pecchioli (2021b) examined the effect of expert assessments on single malt Scotch whisky prices. They show that quality assessment is not a strong predictor of the prices being asked by investors. In addition to these hedonistic factors, that is, the evaluation of the properties or characteristics of whisky that provide utility to consumers, market-specific factors that influence the prices of whisky also exist.

The purpose of this paper is, therefore, to investigate the market-specific factors driving the price of whisky, to analyze the risk-return characteristics of rare whisky, and to compare these characteristics to those of traditional and alternative asset classes. Furthermore, we investigate whether rare whisky can lead to performance improvements of a multi-asset portfolio consisting of stocks, bonds, hedge funds, private equity, commodities, and fine wine, and what share rare whisky has in portfolios embodying different investment strategies. The remainder of this article is organized as follows: The next section provides an introduction to the whisky market and the driving factors of its prices, and gives an overview of the vehicles through which one can invest in rare whisky. The third section explains the methodology. The fourth section describes the dataset, and the fifth section presents and discusses the results. The final section concludes.

THE WHISKY MARKET AND INVESTMENT OPPOTUNITIES

The Whisky Market

The world whisky market is a global market dominated by Scotch whisky. Scotch whisky is the number-one internationally traded spirit, with exports of GBP 4.9 billion in 2019 (Gordon 2020). In recent years, however, Irish, American, Canadian, and Japanese whiskies also have been increasing their global penetration in many markets. Furthermore, the demand for premium whisky has increased sharply due to a growing luxury consumer base, the increasing demand from emerging markets, and the growing middle-class population in the Asia-Pacific region (Buxton and Hughes 2021).

EXHIBIT 1**Scotch Whisky Production 1946–2019 in Millions of Liters of Pure Alcohol (mlpa)**

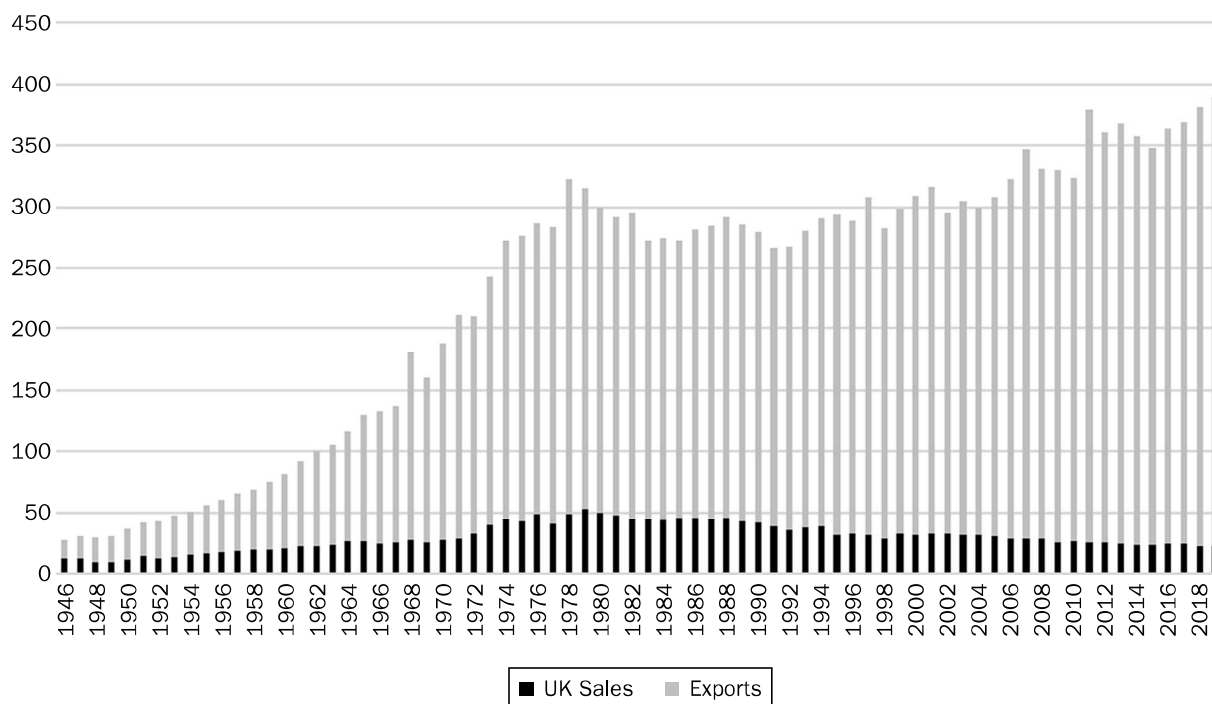
SOURCE: Bower (2016) and Gordon (2020).

In principle, supply increases with demand for most products. This is not the case with whisky. A peculiarity of this market is that the production of whisky suffers from an unavoidable delay resulting from the need to mature the product. Thus, the law in Scotland requires the spirit to be aged in a wooden cask for three years in order for the distillate to be referred to as Scotch whisky (Page 2019). Premium whiskies take significantly more time, maturing for 12 to 16 years, while the most luxurious whiskies are aged as long as 25 or even 60 years. The producer of a 25-year-old whisky in 2021 is dependent on the decisions made in 1996 or earlier under very different market conditions. To be able to market a 25-year-old product in 2046, stocks must be created and reserved today. Exhibit 1 shows the production of Scotch whisky since 1946.

Exhibit 1 shows that the production volume of grain whisky is fundamentally higher than that of malt whisky. This is because blended Scotch whisky brands consist of 60% grain spirit and 40% malt spirit (Bower 2016). Furthermore, it is evident that Scotch whisky production is very cyclical and subject to strong fluctuations. If we examine global Scotch whisky consumption since 1946, which is shown in Exhibit 2, it has increased obviously over the past 10 years.

One of the main drivers of rising consumption over the past 10 years has been the increasing demand from emerging markets and the Asia-Pacific region. Exhibit 3 summarizes the leading 10 export markets for Scotch whisky.

The figures for India, Japan, and Mexico show that these countries have shown the highest export growth over the past 10 years.

EXHIBIT 2**World Scotch Whisky Consumption 1946–2019 in mlpa**

SOURCE: Bower (2016) and Gordon (2020).

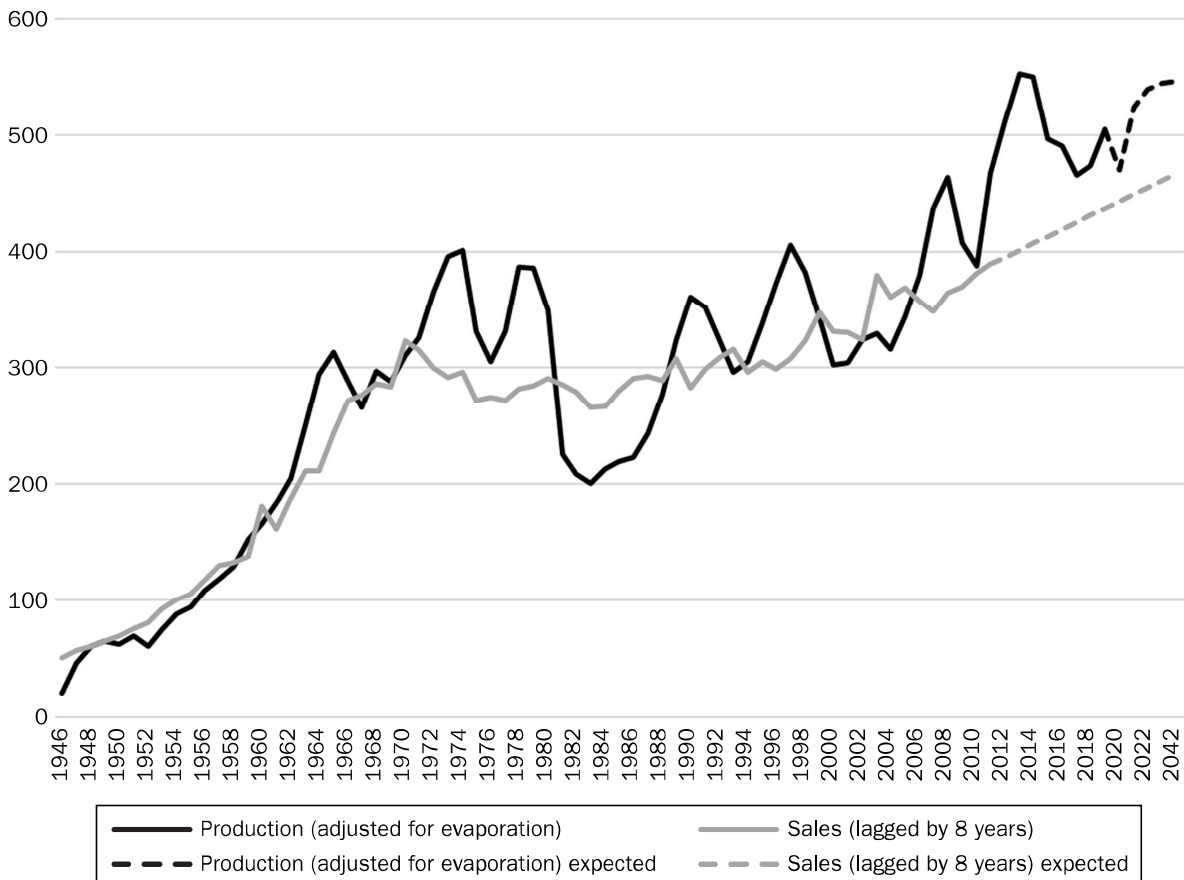
EXHIBIT 3**Leading Export Markets for Scotch Whisky**

| Country | 2019 in mlpa | % of Total | 2009 in mlpa | % of Total |
|-------------------------|--------------|------------|--------------|------------|
| France | 48.54 | 13.24 | 50.12 | 16.47 |
| India | 36.63 | 9.99 | 8.64 | 2.84 |
| United States | 35.62 | 9.71 | 29.35 | 9.64 |
| Japan | 16.92 | 4.61 | 2.75 | 0.90 |
| Spain | 15.84 | 4.32 | 24.49 | 8.05 |
| Mexico | 14.40 | 3.93 | 6.31 | 2.07 |
| Germany | 13.90 | 3.79 | 10.07 | 3.31 |
| Singapore* | 12.27 | 3.35 | 14.53 | 4.77 |
| Brazil | 11.99 | 3.27 | 8.36 | 2.75 |
| South Africa | 11.73 | 3.20 | 14.01 | 4.60 |
| Total of the 10 Markets | 217.85 | 59.42 | 168.63 | 55.41 |
| All Other Markets | 148.80 | 40.58 | 135.71 | 44.59 |
| Total Exports | 366.65 | 100.00 | 304.34 | 100.00 |

SOURCE: Gordon (2020). *Singapore serves as a hub for exports to various markets in the region (mainly China).

Comparing Exhibits 1 and 2, it is clear that the economic success of the industry is highly dependent on the accuracy of demand forecasts and the associated adjustment of production. The industry has not done this well since the mid-20th century. Various patterns of overproduction in an environment of positive demand growth and underproduction in periods of declining demand are evident, particularly in the

EXHIBIT 4
The Scotch Whisky Cycle

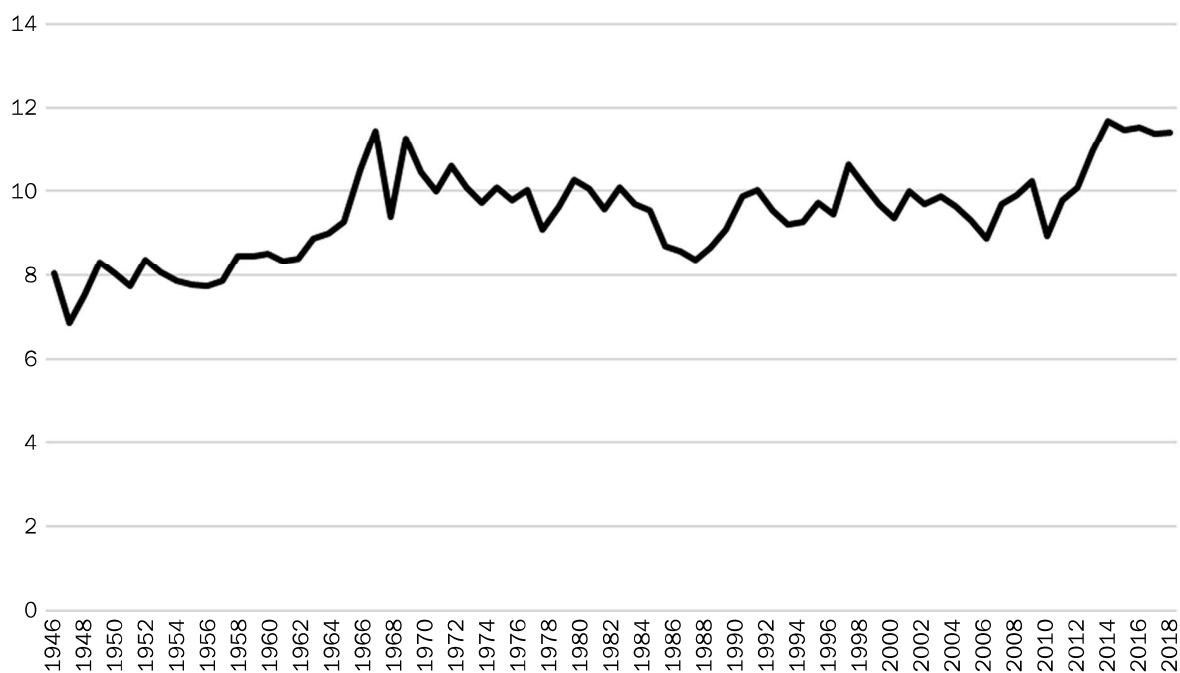


SOURCE: Bower (2016) and Gordon (2020). Annual totals in mlpa. It is assumed that 16% of production is lost to evaporation on a straight line basis for an average maturation age of eight years.

1970s and 1980s. This led to what the industry refers to as the stock or whisky cycle. Exhibit 4 shows the relationship between actual production and future sales.

It is clear that the industry’s production profile is characterized by sharp cuts followed by equally sharp reversals. Scotch whisky produced today is consumed in an average of eight years, although it only needs to mature for three years to be legally sold as Scotch whisky (Bower 2016). To further account for the fact that the whisky evaporates each year it matures in the cask, the production volume must be adjusted downward. This is referred to as the “angel’s share.” Since the UK government uses an average of 2% evaporation per year per cask, the current production volume is reduced by 16% (Bower 2016). The dashed black line in the chart shows the forecast of whisky production for 2020 to 2024 made by Gordon (2020). In contrast, the dashed grey line in the chart is not a sales forecast. This line shows the trend of actual sales from 2010–2019, during which sales increased by an average of approximately 6 mlpa per year. This approach is consistent with that of Bower (2016), and shows sales of whisky produced eight years ago in the 2012 to 2024 period.

When the production line is above the lagged sales line, the industry is overproducing; and in the opposite case, the industry is underproducing. The reason for this

EXHIBIT 5**Stock-to-Sales Ratio**

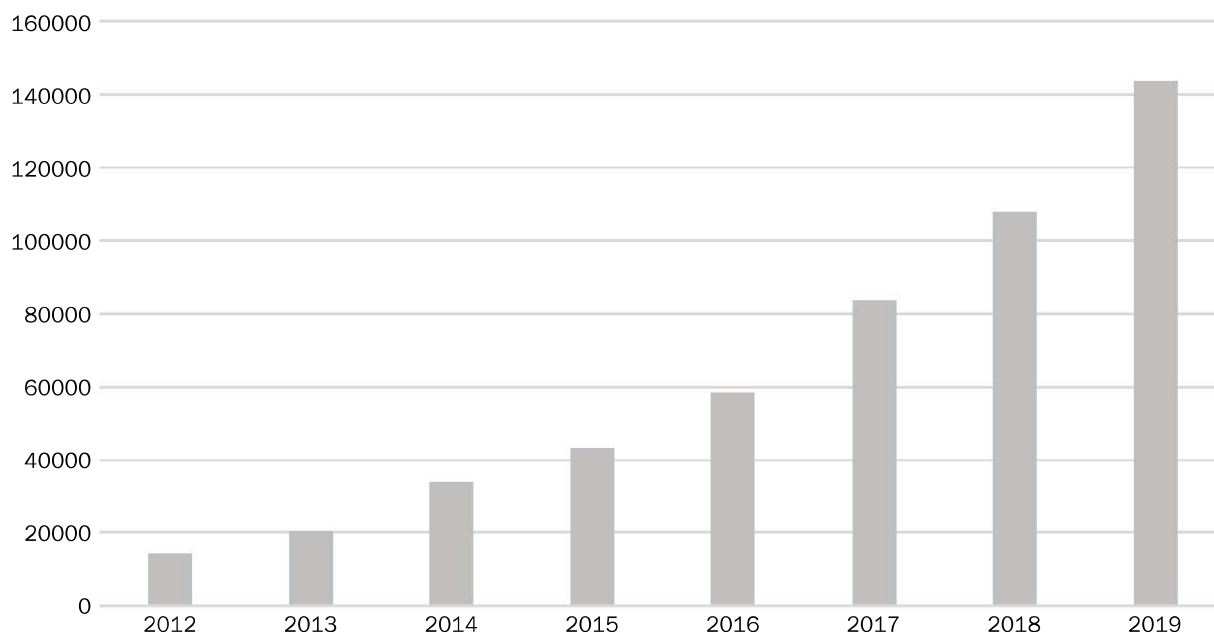
SOURCE: Bower (2016) and Gordon (2020).

can be seen in Exhibit 5, where the deviation from an ideal stock to current sales ratio of approximately 9.5 years (reflecting the average 8-year product and accounting for evaporation) is the trigger for these sharp changes in production.

The difficulty of managing production and stocks is compounded by a simultaneous increase in carry costs (stock financing) such that smaller manufacturers quickly come under pressure to both cut production and reduce stocks. The massive overproduction of the 1970s came to a halt in the mid-1980s when the industry virtually collapsed. This led to Scotland's "whisky loch" in the mid-1980s, resulting in the closure of nearly 30 distilleries between 1983 and 1987 (Buxton and Hughes 2021). Furthermore, during this period, many casks that had been stored prior to the collapse were "decommissioned" to mature. In the late 1990s and early 2000s, this resulted in an oversupply or "loch" of aged premium whisky available on the market at comparatively low prices. Then, in the mid-2000s, the oversupply began to even out; and toward the end of the 2000s, demand began to exceed supply. Old vintages of premium whiskies became increasingly rarer and were able to record strong price increases due to continuing demand. Furthermore, increasingly more "non-age statement (NAS)" whiskies (i.e., whiskies without an age statement) came onto the market for reasons of availability.

The incipient supply shortage of old vintages of premium whiskies led a large number of new online auction houses specializing in whisky to enter the market, and traditional auction houses also began to initiate online auctions. These developments allow passionate whisky drinkers and collectors from around the world to bid on rare bottles. Exhibit 6 shows the number of single malt Scotch whisky bottles sold at auction in the United Kingdom for the years 2012 to 2019.

In 2012, 14,150 bottles were sold at auction. In 2019, the number was 14,3895, representing a growth rate of 917%. This development also has significantly increased the liquidity of rare whisky bottles. As a result, the trading costs associated with the sale of rare whisky bottles decreased as auction houses competed for the best

EXHIBIT 6**Number of Recorded Bottles of Single Malt Scotch Whisky Sold at Auction in the UK**

SOURCE: Rare Whisky 101 Ltd.

stocks. Currently, online auctions in the UK are charged a registration fee of GBP 5. The seller also pays a listing fee of GBP 5 per bottle and, depending on the online auction, a sales commission of between 0% (e.g., www.scotchwhiskyauctions.com) and 5% (e.g., www.whiskyauctioneer.com) of the final hammer price. The buyer, meanwhile, pays a buyer's commission of 10% of the final hammer price.

The worldwide availability of rare whisky through online auctions has further increased demand and increasingly attracted investors. These developments are reflected in the prices of both common and rare whiskies. If a certain bottle is sold in an auction for an exceptional price, this is communicated in online forums, and media attention increases. This creates trends that have a positive impact on the prices of other bottles. Exhibit 7 shows the average price per auctioned single malt Scotch whisky bottle in the United Kingdom for the years 2012 to 2019.

The price was GBP 206 in 2012 and GBP 401 in 2019, an increase of 95%. Finally, to provide an overview of the size of the investable secondary market for rare whisky, Exhibit 8 summarizes the value of bottles of single malt Scotch whisky auctioned in the United Kingdom in millions of GBP.

In 2012, bottles worth the equivalent of GBP 2.9 million were sold at auctions. In 2019, the value was GBP 57.7 million, a growth rate of 1,882%. Nevertheless, the whisky online auction market is still a relatively young and small market compared to fine wines, making the analysis of price trends much more difficult.

Investment Opportunities

The easiest way to invest in rare whisky is to buy and store bottles. Storage costs are relatively low because—unlike wine, which continues to age in the bottle—no special storage space is required. Whether there are other costs associated with the purchase depends on where the bottles are purchased. For example, there are no additional costs when buying through specialized distributors. If the bottles are

purchased through online auctions, 10% transaction costs are added to the hammer price. In addition, transaction costs of up to 5% may be incurred on the sale.

The key price driving factors for whisky bottles are age and rarity. In terms of age, it is still necessary to differentiate between whisky age (the time spent in the cask) and bottle age (the time spent in the bottle), with whisky age having a stronger effect on price than bottle age. Moroz and Pecchioli (2019) examined the main determinants of differences in investor-set bid prices for single malt whiskies traded on www.worldwhiskyindex.com, a web trading platform specializing in investment single malt Scotch whiskies. They found that each year whisky is aged in a cask increases the offer price by 8.9%. Once the aging process is complete and the whisky is bottled, each additional year of bottle aging results in a 6.7% price increase. In addition, since whisky was originally produced for consumption, it is subject to a natural limitation. Often, the best whiskies are consumed by whisky enthusiasts, making the remaining bottles both rare and in demand. This makes a rare whisky even rarer in quantity.

An example of the effect of age and rarity is the Macallan 1979 18-year-old Gran Reserva, which was bottled in 1997 and then offered at retail prices of GBP 50. In 2016, the whisky sold at auction for GBP 1,200; and today, it trades at a price of over GBP 6,000. Today, bottles trading for GBP 10,000 and more are not uncommon. In addition, there are some very exclusive bottles that have achieved prices of well over GBP 100,000. The most famous example is certainly the whisky of the brand “The Macallan Fine and Rare 60 Year Old 1926.” In the fall of 2019, a bottle of The Macallan Fine and Rare 60 Year Old 1926 was auctioned at Sotheby’s for 1.5 million GBP—the highest price ever achieved for a bottle of whisky.

Other price driving factors include the distillery and the brand (Moroz and Pecchioli 2019). Here, the strongest demand is found for single malt whiskies from established distilleries in Scotland. Due to increasing demand and limited supply, rare Japanese whiskies also have gained popularity in recent years.¹ Because, unlike a bottle of wine, a bottle of whisky has no optimal consumption date, the intrinsic properties of a bottle of whisky, that is, the sensory attributes related to the tasting experience, are time-independent for two reasons (Moroz and Pecchioli 2019). First, the intrinsic characteristics of a whisky do not depend on the climatic conditions of its vintage, that is, its distillation year. Second, a bottle of whisky has no aging potential; its intrinsic properties do not change over time. Unlike wine, which continues to age in its bottle, a whisky’s aging process stops once it has been bottled, and its age only corresponds to the time it has spent in casks between its distillation date (i.e., its vintage) and its bottling date. For investors, this means they cannot anticipate the price of a bottle of whisky by relying on data such as the climatic conditions of a particular vintage or expectations of an optimal consumption date.

Against this backdrop, quality ratings provided by experts are highly significant in assessing the value of a bottle of whisky. Quality ratings are published by whisky experts (e.g., Jim Murray, Serge Valentin) as well as by specialized magazines (e.g., *Whisky Magazine*, *Whisky Advocate*) and websites (e.g., Scotchwhisky, Connors).² However, the effect of expert reviews on the prices of single malt Scotch whiskies should be interpreted with caution. In this context, Moroz and Pecchioli (2021b) show that, based on the Jim Murray rating, quality rating is not a strong predictor of

¹ Information on the bottles of the most traded distilleries as well as on the price trends of the bottles of the respective distilleries can be found on the websites of Rare Whisky 101 (www.rarewhisky101.com) and Whiskystats (www.whiskystats.net).

² Significant critics, journals, and websites are mainly Jim Murray (www.whiskybible.com), Serge Valentin (www.whiskyfun.com), Ruben Luyten (www.whiskynotes.be), Dave Broom (www.thewhiskymanual.uk), *Whisky Magazine* (www.whiskymag.com), *Whisky Advocate* (www.whiskyadvocate.com), Scotchwhisky (www.scotchwhisky.com), Connorsr (www.connorsr.com).

the prices demanded by investors. They conclude that while the Murray rating may contain information useful to unsophisticated investors, its effect on price may be exceeded by detailed knowledge of the whisky industry.

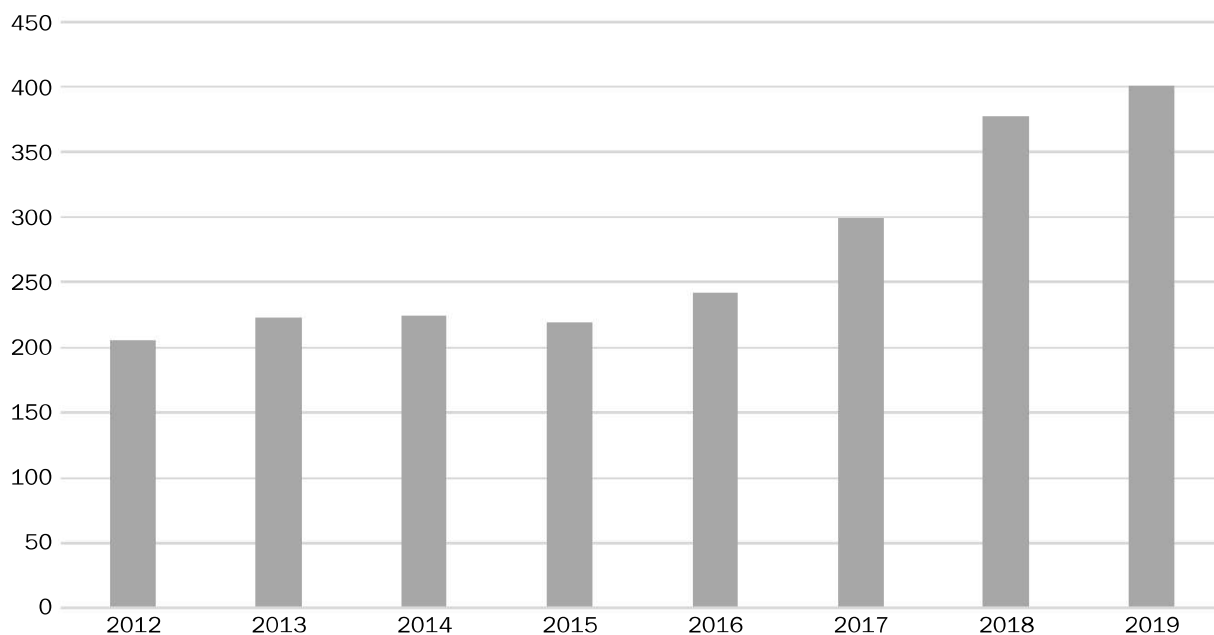
As the market for investing in rare whisky bottles has grown rapidly and the most valuable bottles have become increasingly difficult to find, there is growing interest in investing in whisky casks. Casks can be purchased directly from distilleries, who in the past have often used this model to increase their liquidity, as the whisky business is very capital intensive. However, in the past 10 years, many distilleries have greatly reduced these programs due to the logistical difficulties of the B2C cask ownership model. Alternatively, whisky casks can be purchased through cask brokers. By law, Scotch casks must be stored in bonded HMRC-regulated warehouses in Scotland. The associated storage costs average GBP 30 per year per cask. The investor has the option of purchasing either a newly filled cask or an older cask that has had years of maturing. Prices for a whisky cask start at approximately GBP 1,500, and the rarest casks reach prices in excess of GBP 3 million. As a rule, the minimum holding period should be at least five years.

Regarding the sale of a cask, there are different possibilities. A cask broker can sell a cask to another customer through its in-house brokering service; a cask can be sold on the open market, or the cask broker can buy the cask back himself; or there is the possibility of auction sales. If whisky casks are purchased through cask brokers who then also are entrusted with the management and administration of the casks, they usually receive 10% of the profit from the sale of the cask at the end of the investment. The value of a whisky cask depends mainly on the year of production, the type of cask, the distillery, the original liters of alcohol (OLA), the remaining liters of alcohol (RLA), and the alcohol by volume (ABV). In contrast to the purchase of bottles, the purchase of a whisky cask involves more risks. A cask may have off-flavors that ruin the whisky during maturing; the alcohol in the whisky may evaporate excessively during the maturing process; or the whisky may peak too early, affecting its resale value.

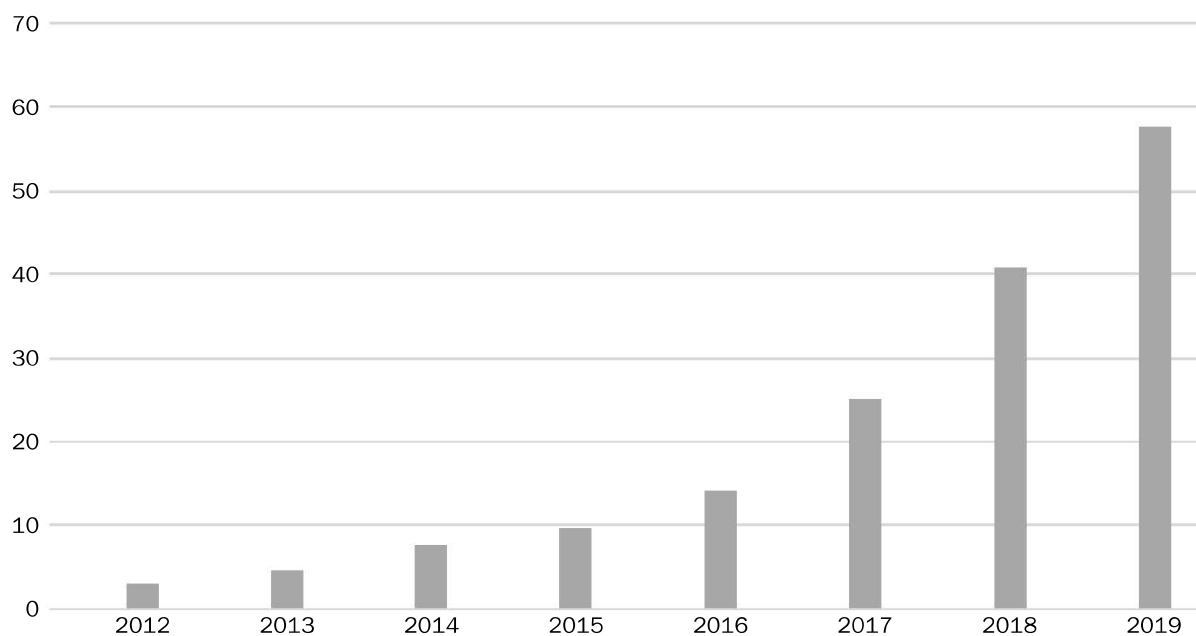
The strong price increases for rare whisky observed since 2010 also have led to institutional investors beginning to take an interest in rare whisky. In 2014, for example, the “Platinum Whisky Investment Fund”—a closed-end private equity fund investing in rare single malt whisky bottles—was established with a fund volume of US\$10 million. It has an annual management fee of 1.5% and a performance fee of 20%. Last year, the “Rare Finds Worldwide’s Rare Single Malts Fund” was established, also organized like a private equity fund, with the aim of raising a target volume of GBP 20 million. In addition to investing in rare whisky bottles and bottle collections, this fund also invests in whisky casks. In March 2020, a liquid vehicle for whisky investments, the “Single Malt Fund,” was listed for the first time on the Nordic Growth Market in Stockholm. Its planned fund volume is EUR 25 million. The fund will pursue an active investment strategy by buying and selling rare whisky bottles and whisky casks. Its management fee is 2.5% a year plus a performance fee of 20%.

In 2020, Wave Financial Group, a company specializing in digital assets, launched the “Wave Kentucky Whiskey 2020 Digital Fund” in partnership with Kentucky-based Wilderness Trail Distillery. The fund plans to invest in newly filled casks of premium Kentucky bourbon whiskey in the range of 10,000 to 20,000 casks, with a volume of approximately US\$20 million, and then store them for maturing. Investors then can purchase shares in the fund that will be represented by tokens that subsequently can be traded on digital security exchanges. The fund has a 5% upfront acquisition fee, an annual management fee of 1%, and a performance fee of 15%.

Finally, investors still have the option of investing in whisky indirectly via stocks in listed beverage companies. Examples include Diageo, which has the largest market

EXHIBIT 7**Average Per-Bottle Price of Single Malt Scotch Whisky Sold at Auction in UK in GBP**

SOURCE: Rare Whisky 101 Ltd.

EXHIBIT 8**Recorded Value of Bottles of Single Malt Scotch Whisky Sold at Auction in the UK in Million GBP**

SOURCE: Rare Whisky 101 Ltd.

share of the Scotch whisky business and is responsible for more than a third of all whisky produced in Scotland. Other examples are the Johnnie Walker blends and distilleries such as Lagavulin, Mortlach, and Talisker. With a market share of approximately 19%, Pernod Ricard of France is the second-largest whisky producer.

EXHIBIT 9

Overview of the Different Portfolio Models

| # | Model | Abb. | Objective Function | Type | Constraints |
|---|----------------------------|------|---|----------|--|
| 1 | Minimum Variance Portfolio | MVP | $w' \Sigma w$ | Minimize | $w'1 = 1, w' \geq 0$ |
| 2 | Tangent Portfolio | TP | $\frac{w' \mu - r_f}{\sqrt{w' \Sigma w}}$ | Maximize | $w'1 = 1, w' \geq 0$ |
| 3 | Naïve Portfolio (1/N Rule) | NP | | | |
| 4 | Naïve Return Portfolio | RP | $w' \Sigma w$ | Minimize | $w'1 = 1, w' \geq 0, w' \mu_{RP} = \mu_{NP}$ |

NOTE: w denotes the vector of portfolio weights, μ denotes the vector of the expected asset returns and portfolio returns, and Σ denotes the variance-covariance matrix of the asset returns.

In addition to all the Chivas Brothers distilleries, whiskies such as Glenlivet, Aberlour, and Jamesons also belong to Pernod Ricard. As both companies are beverage producers, they also produce a variety of other alcoholic beverages, including gin, rum, and vodka. Thus, this is not only an indirect investment in whisky but also a general investment in spirits.

METHODOLOGY

To investigate the diversification properties of investments in rare whisky, we use the mean-variance approach of Markowitz (1952) and analyze the extent to which rare whisky is actually a component of selected portfolios representing different investment strategies. The starting point of the analysis is a multi-asset base portfolio (MABP) consisting of stocks, bonds, hedge funds, private equity, commodities, real estate, and fine wine. This is then extended to include rare whisky for analysis purposes. The portfolios under consideration are the minimum variance portfolio, the tangential portfolio, the naïve portfolio, and a portfolio that has the same return as the naïve portfolio but is located on the efficient frontier. The four portfolios are summarized in Exhibit 9.

Each of the four portfolios exists in two variants. The first variant corresponds to the multi-asset base portfolio (MABP) without rare whisky, and the second adds rare whisky as an asset class to the multi-asset base portfolio (MABPW). For each of the four portfolios, we calculate the Sharpe ratios for the variant without rare whisky and the variant with rare whisky. We then use the test procedure of Gibbons et al. (1989) to examine whether the Sharpe ratios of the portfolios with rare whisky (MABPW) differ significantly from the corresponding portfolios without rare whisky (MABP). For this, Gibbons et al. (1989) developed the following test statistic:

$$W = \left(\frac{\sqrt{1 + SR_{MABPW}^2}}{\sqrt{1 + SR_{MABP}^2}} \right)^2 - 1 \tag{1}$$

where SR_{MABP} is the Sharpe ratio of the multi-asset base portfolio without rare whisky and SR_{MABPW} is the Sharpe ratio of the multi-asset base portfolio with rare whisky.

Measuring a value of W that differs significantly from zero would mean that one of the portfolios under investigation outperforms the other with respect to its mean-variance properties in a statistically significant manner. The Wishart distributed test statistic W can be transformed into an F-distributed test statistic:

$$\frac{T(T-N-1)}{N(T-2)}W \sim F_{N,(T-N-1)} \quad (2)$$

where T is the number of observations

N is the number of assets

The transformation only applies to nonnegative values of W. To test whether the portfolio that contains rare whisky produces a statistically significant better Sharpe ratio, Equation 1 is straightforward as long as $SR_{MABPW} > SR_{MABP} \geq 0$ holds. Otherwise, the equation has to be modified accordingly. The power of the test statistic depends on the relationship between T and N. Gibbons et al. (1989, p. 1136) mentioned a threshold of $T/N \geq 3$, which is straightforward for our dataset.

DATA AND PRELIMINARY ANALYSIS

Within the study, the international asset classes of rare whisky, stocks, bonds, hedge funds, private equity, commodities, real estate, and fine wine are considered. The proxy for rare whisky is the Rare Whisky Apex 1000 Index, which is calculated and published by Rare Whisky 101 Ltd. The Rare Whisky Apex 1000 is the leading index for Scotch whisky and is based on a database that contains factual and accurate open market values for the sale of 727,268 bottles of single malt Scotch covering 62,401 different bottlings. The Rare Whisky Apex 1000 Index documents the performance of 1,000 of the most sought-after bottles of single malt Scotch. The bottles included in the index are regularly traded at auctions in the United Kingdom. The bottles included in the index were carefully selected to provide the most representative index basket possible, documenting the performance of collectible Scotch bottles (Rare Whisky 101 Ltd. 2021).³

The proxies for the international equity and bond markets are the MSCI World Investable Market Index and the J.P. Morgan Global Government Bond Index. Furthermore, we use the HFRX Global Hedge Fund Index as a proxy for hedge funds and the GPR 250 Index to measure global listed real estate. We use the Refinitiv/Core Commodity CRB Index as a proxy for commodities, and the LPX 50 Index as a proxy for globally listed private equity. All six indexes are calculated as total return indexes.

Finally, the asset class of fine wine is represented by the Liv-ex Fine Wine Investables Index. The Liv-ex Fine Wine Investables Index tracks the most investable wines in the market, viz. approximately 200 wines from 24 top Bordeaux chateaux. In essence, it aims to mirror the performance of a typical wine investment portfolio.

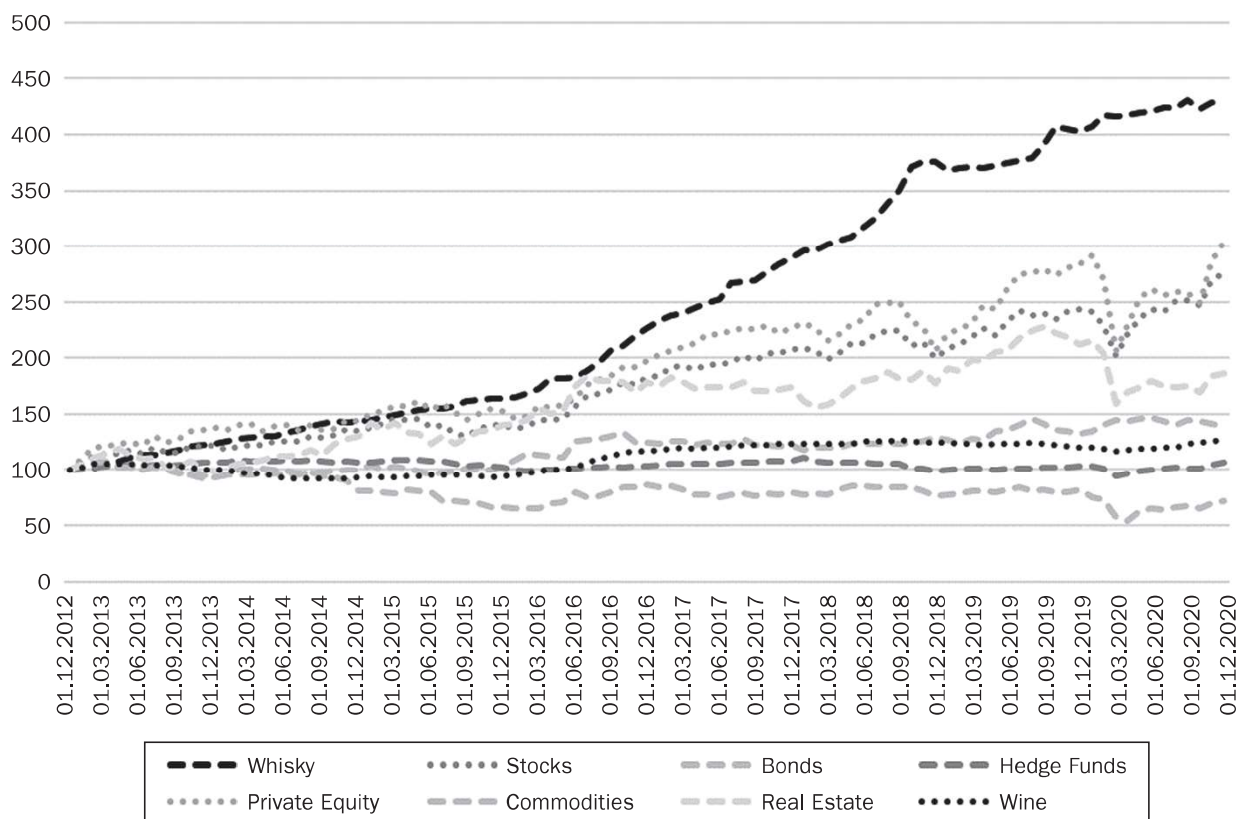
All indexes are denominated in GBP and the analysis is, therefore, based on the perspective of British investors. The calculations are made on the basis of discrete monthly returns. The study period is January 2013 to December 2020, and the one-month UK Libor is used as the risk-free interest rate. The reason for the choice of the period under observation is that the Rare Whisky Apex 1000 Index was first calculated on a monthly basis starting mid-2012. Prior to that, the index was calculated on a quarterly basis.

To obtain a first impression of the performance of rare whisky assets, Exhibit 10 shows the indexed performance of the Rare Whisky Apex 1000 Index compared to the other asset classes.

³No further information is provided on the bottles included in the Rare Whisky Apex 1000 index basket due to the high number. However, Rare Whisky 101 Ltd. calculates further indexes, such as distillery specific indexes, collector specific indexes, and distillery rankings. For these, there is also further information such as detailed information on the bottles included in the respective indexes including region, distiller, bottler, vintage, age, ABV, etc. For more information about Rare Whisky 101 Ltd. and the indexes it calculates, see www.rarewhisky101.com.

EXHIBIT 10

Development of the Indexes under Observation (indexed January 2013 = 100)



SOURCE: Rare Whisky 101 Ltd. and Macrobond

Within the period under investigation, rare whisky recorded by far the highest increases in value. The descriptive statistics of the discrete monthly returns of the indexes that were considered are summarized in Exhibit 11.

Within the investigation period, rare whisky had the highest average monthly return of 1.54%. The average monthly returns of the other asset classes ranged from 1.28% for listed private equity to -0.24% for commodities.

What also becomes apparent are the significant positive first-order autocorrelations of rare whisky and fine wine returns. The main reason for this is that fine wine and rare whisky markets are less liquid markets (Masset and Weisskopf 2018). Bottles of rare whisky are traded at auctions while fine wine, for example, is traded on the London International Vintners Exchange (Liv-ex). In contrast to stock and bond exchanges, these trading venues have significantly lower liquidity. This can lead to transaction prices being based on the last price (possibly even farther back in time), resulting in “smoothed” returns. Such returns typically exhibit high autocorrelation and low volatility at the same time (Brooks and Kat 2002). The extent of the bias in the volatility calculation can be estimated by resorting to the adjustment procedure of Geltner (1993). In this procedure, a new “desmoothed” return is generated from the observed “smoothed” return. This is done using the following formula:

$$r_t = \frac{r_t^* - \alpha \times r_{t-1}^*}{1 - \alpha} \tag{3}$$

EXHIBIT 11 Descriptive Return Statistics

| | Mean | SD | Min. | Max. | Sharpe Ratio | SV | 90% VaR | MDD | Skewness | Kurtosis | JB Test | AC(1) |
|------------------|--------|-------|---------|--------|--------------|-------|---------|---------|----------|----------|-----------|--------|
| Rare Whisky (sm) | 1.54% | 1.52% | -2.01% | 6.36% | 0.99 | 0.94% | -0.03% | -2.01% | 0.80 | 4.03 | 14.51*** | 0.26** |
| Rare Whisky (ds) | 1.54% | 1.98% | -2.91% | 7.49% | 0.76 | 1.26% | -0.71% | -3.77% | 0.64 | 3.90 | 9.86*** | -0.02 |
| Stocks | 1.12% | 3.41% | -11.75% | 9.18% | 0.32 | 2.54% | -2.92% | 17.02% | -0.52 | 4.54 | 13.83*** | -0.05 |
| Bonds | 0.38% | 2.65% | -6.60% | 12.81% | 0.13 | 1.72% | -2.65% | -11.75% | 0.89 | 6.93 | 74.45*** | -0.04 |
| Hedge Funds | 0.08% | 1.34% | -6.68% | 2.72% | 0.03 | 1.07% | -1.33% | -14.35% | -1.58 | 8.94 | 181.02*** | 0.09 |
| Private Equity | 1.28% | 4.78% | -23.60% | 14.75% | 0.26 | 3.66% | -4.15% | -29.28% | -1.22 | 9.89 | 214.09*** | 0.04 |
| Commodities | -0.24% | 4.48% | -21.18% | 15.07% | -0.06 | 3.27% | -5.16% | -49.55% | -0.55 | 8.30 | 117.16*** | 0.11 |
| Real Estate | 0.77% | 4.71% | -21.76% | 14.55% | 0.15 | 3.58% | -4.99% | -29.72% | -0.93 | 7.51 | 94.94*** | -0.07 |
| Fine Wine (sm) | 0.25% | 1.12% | -2.08% | 4.47% | 0.19 | 0.69% | -0.96% | -12.97% | 0.93 | 5.00 | 30.00*** | 0.61** |
| Fine Wine (ds) | 0.25% | 2.24% | -3.92% | 8.69% | 0.09 | 1.37% | -2.51% | -18.35% | 1.09 | 5.34 | 40.83*** | -0.05 |

NOTES: All numbers are based on discrete monthly returns during the period from January 2013 to December 2020 (96 observations). Sm denotes smoothed returns, and ds denotes desmoothed returns. The Sharpe ratio relates the arithmetic average of the monthly excess return of the index under consideration over the one-month UK Libor to the standard deviation (SD). Semivolatility (SV) only includes negative deviations from the mean. The value-at-risk (VaR) indicates the loss that will not be exceeded with a probability of 90% within one month. Maximum drawdown (MDD) shows the maximum loss caused by consecutive loss months. The Jarque-Bera test (JB test) checks whether the returns are normally distributed. */**/**** indicate statistical significance better than 10%/5%/1%, respectively. AC(i) displays the autocorrelation coefficient for the lag of i months.

EXHIBIT 12

Pearson Correlation of Monthly Returns

| | Rare Whisky | Stocks | Bonds | Hedge Funds | Private Equity | Commodities | Real Estate | Fine Wine |
|----------------|-------------|--------|-------|-------------|----------------|-------------|-------------|-----------|
| Rare Whisky | 1.00 | -0.09 | -0.11 | 0.02 | -0.05 | 0.15 | -0.03 | 0.00 |
| Stocks | | 1.00 | 0.09 | 0.76 | 0.90 | 0.54 | 0.69 | 0.28 |
| Bonds | | | 1.00 | -0.35 | -0.05 | 0.13 | 0.41 | 0.41 |
| Hedge Funds | | | | 1.00 | 0.82 | 0.43 | 0.42 | 0.04 |
| Private Equity | | | | | 1.00 | 0.50 | 0.65 | 0.25 |
| Commodities | | | | | | 1.00 | 0.39 | 0.26 |
| Real Estate | | | | | | | 1.00 | 0.29 |
| Fine Wine | | | | | | | | 1.00 |

NOTE: All numbers are based on discrete monthly returns during the period from January 2013 to December 2020 (96 observations).

where r_t and r_t^* are the true underlying (unobservable and “desmoothed”) return and the observed (“smoothed”) return at time t , respectively. α denotes the autocorrelation coefficient with a lag of 1. The newly constructed series, r_t , will have the same mean as r_t^* and zero first-order autocorrelation (aside from rounding errors). The volatility of the desmoothed series increases (decreases) when the first-order autocorrelation coefficient is positive (negative). Given that the first-order autocorrelation coefficients are positive in our case, the transformation generates higher volatilities for rare whisky and fine wine returns while their mean return remains unchanged. The volatility for rare whisky returns is 1.52% for smoothed returns and 1.98% for desmoothed returns. In contrast, the volatility of fine wine is 1.12% for smoothed returns and 2.24% for desmoothed returns. The volatilities of the other asset classes range from 1.34% for hedge funds to 4.78% for private equity.

The high expected return of rare whisky in combination with the low volatility is also reflected in the Sharpe ratio, which is highest at 0.99 for the smoothed returns and 0.76 for the desmoothed returns. In terms of downside risk—measured by the semivolatility, value-at-risk, and maximum drawdown—rare whisky has the lowest downside risk in the desmoothed returns with the exception of semivolatility. In terms of semivolatility, this turns out to be lowest for hedge funds at 1.07%.

Examining further risk measures in the form of the higher moments, the returns of rare whisky, bonds, and fine wine exhibit positive skewness. This indicates a lower probability of negative monthly returns compared with the normal distribution and, thus, implies a lower risk of loss. In addition, the returns of all asset classes under investigation show a kurtosis above 3. This means that there is more probability mass in the tails and center of the distribution, indicating that the probability of particularly large positive or negative returns is higher than in a normal distribution. However, the kurtosis is lowest for rare whisky. Finally, the Jarque-Bera test statistic shows that none of the asset classes considered have returns that follow a normal distribution.

To obtain a first impression of the diversification potential of rare whisky, Exhibit 12 shows the correlation structures of the returns of the asset classes considered. For fine wine and rare whisky, we used the desmoothed returns, as these are also used for the subsequent investigation of the diversification potential of rare whisky.

Rare whisky returns show a slightly negative correlation with stocks, bonds, private equity, and real estate. The correlation of returns with hedge funds and fine wine is close to zero, and the correlation with commodities is also very low, at 0.15. Against this background, it can be assumed that rare whisky offers attractive diversification opportunities.

EMPIRICAL RESULTS AND DISCUSSION

Empirical Results

Due to the predominantly slightly negative correlations between the returns of rare whisky and those of the other asset classes under investigation, rare whisky can play a significant role in investors' portfolios. We now analyze this using the methodology presented in the section above. Exhibit 13 summarizes the results of the comparison between the multi-asset base portfolio and the multi-asset base portfolio to which rare whisky was added.

Examining the results in Panel A, where no further restrictions are placed on the minimum or maximum allocations of the asset classes considered in the portfolio construction process, adding rare whisky to an international multi-asset base portfolio (MABP) demonstrates that rare whisky is economically significant for any investment strategy. This is reflected in the high proportions of rare whisky within the portfolios, ranging from 69.45% for the tangent portfolio (TP) to 21.08% for the minimum variance portfolio (MVP). The high proportions of rare whisky result from its more attractive risk-return characteristics and the predominantly slightly negative correlations of its returns with those of other asset classes. Comparing the Sharpe ratios of the portfolios with and without the inclusion of rare whisky, all portfolios that include rare whisky have a clearly higher Sharpe ratio. In order to be able to judge the extent to which the economic performance improvement through the addition of rare whisky is also statistically significant, we consider the results of the test procedure of Gibbons et al. (1989). According to this, a statistically significant improvement in performance at the 1% level can be demonstrated for all portfolios considered except the naïve portfolio.

It should be noted in this context that the very high proportions of rare whisky in the respective portfolios are practically impossible to implement as part of a real investment strategy. Furthermore, not all asset classes are considered in the portfolio construction. Against this background, we introduced additional constraints in the context of portfolio optimization. The maximum allocation weighting of each asset class was limited to 25%. This maximum allocation restriction is intended to prevent portfolios from being dominated by a single asset class. In addition, each asset class has a minimum share of 5% in the portfolio.

The results considering the additional constraint are summarized in Panel B. Considering these additional constraints, the differences between the Sharpe ratios of the respective portfolios decreased, as expected. However, a significant performance improvement at the 10% level can still be achieved for the minimum variance portfolio (MVP).

Discussion

The empirical investigation has shown that adding rare whisky to an international multi-asset portfolio consisting of equities, bonds, hedge funds, private equity, commodities, real estate, and fine wine leads to significant performance improvements. This is true for all portfolios considered, representing different investment strategies. However, these results should be interpreted with caution, as our period of investigation only covered a pure bull market due to data availability. Furthermore, it has been shown that the price drivers for rare whisky are influenced by specific factors such as age effects, scarcity, and the long product cycle, in addition to imbalances between supply and demand. Moreover, the whisky market does not exist in isolation; it is subject to competition from other spirits. Trends and fads have a strong influence on consumer choices. In addition, white spirits such as vodka, gin, and white rum have

EXHIBIT 13**Portfolio Comparison Based on Sharpe Ratios with Significance Tests**

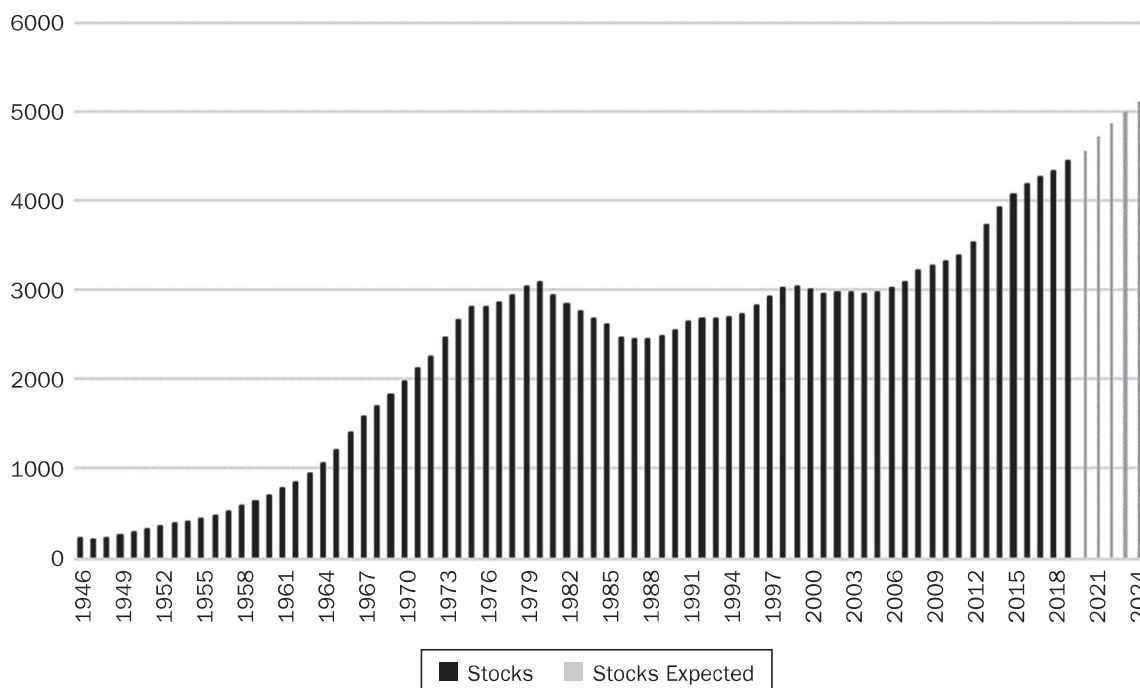
| Portfolios | Panel A: Portfolios without a Minimum and a Maximum Share Weight of Asset Classes | | | | Panel B: Portfolios with a Minimum Share Weighting of 5% and a Maximum Share Weighting of 25% Per Asset Class | | | |
|-----------------------------|---|--------|--------|--------|---|--------|--------|--------|
| | MVP | TP | NP | RP | MVP | TP | NP | RP |
| MABP | | | | | | | | |
| Return | 0.16% | 0.90% | 0.52% | 0.52% | 0.38% | 0.75% | 0.52% | 0.52% |
| SD | 0.97% | 2.59% | 2.42% | 1.68% | 1.65% | 2.55% | 2.42% | 1.91% |
| Sharpe Ratio | 0.12 | 0.33 | 0.20 | 0.28 | 0.20 | 0.28 | 0.20 | 0.25 |
| Weights | | | | | | | | |
| Stocks | 0.00% | 70.46% | 14.29% | 31.74% | 9.85% | 25.00% | 14.29% | 25.00% |
| Bonds | 24.19% | 29.54% | 14.29% | 32.50% | 25.00% | 25.00% | 14.29% | 25.00% |
| Hedge Funds | 70.24% | 0.00% | 14.29% | 29.03% | 25.00% | 5.00% | 14.29% | 20.82% |
| Private Equity | 0.00% | 0.00% | 14.29% | 0.00% | 5.00% | 25.00% | 14.29% | 5.20% |
| Commodities | 0.00% | 0.00% | 14.29% | 0.00% | 5.15% | 5.00% | 14.29% | 5.00% |
| Real Estate | 0.00% | 0.00% | 14.29% | 0.00% | 5.00% | 5.00% | 14.29% | 5.00% |
| Fine Wine | 5.57% | 0.00% | 14.29% | 6.73% | 25.00% | 10.00% | 14.29% | 13.98% |
| MABP and Rare Whisky | | | | | | | | |
| Return | 0.45% | 1.32% | 0.65% | 0.65% | 0.65% | 0.87% | 0.65% | 0.65% |
| SD | 0.85% | 1.47% | 2.13% | 0.90% | 1.13% | 1.72% | 2.13% | 1.31% |
| Sharpe Ratio | 0.49 | 0.88 | 0.28 | 0.67 | 0.47 | 0.48 | 0.28 | 0.46 |
| Weights | | | | | | | | |
| Rare Whisky | 21.08% | 69.45% | 12.50% | 34.53% | 25.00% | 25.00% | 12.50% | 24.69% |
| Stocks | 0.00% | 18.63% | 12.50% | 0.00% | 5.00% | 25.00% | 12.50% | 5.00% |
| Bonds | 20.95% | 11.92% | 12.50% | 20.06% | 20.18% | 25.00% | 12.50% | 19.20% |
| Hedge Funds | 54.90% | 0.00% | 12.50% | 43.66% | 25.00% | 5.00% | 12.50% | 25.00% |
| Private Equity | 0.00% | 0.00% | 12.50% | 0.00% | 5.00% | 5.00% | 12.50% | 5.00% |
| Commodities | 0.00% | 0.00% | 12.50% | 0.00% | 5.00% | 5.00% | 12.50% | 5.00% |
| Real Estate | 0.00% | 0.00% | 12.50% | 0.00% | 5.00% | 5.00% | 12.50% | 5.00% |
| Fine Wine | 3.07% | 0.00% | 12.50% | 1.75% | 9.82% | 5.00% | 12.50% | 11.11% |
| F-Statistic | 2.43 | 6.58 | 0.45 | 3.80 | 1.89 | 1.58 | 0.45 | 1.59 |
| P-Value | 0.02 | 0.00 | 0.89 | 0.00 | 0.07 | 0.14 | 0.89 | 0.14 |

NOTES: All numbers are based on discrete monthly returns during the period from January 2013 to December 2020 (96 observations). In the case of returns for rare whisky and fine wine, desmoothed returns are used.

a significant competitive advantage, as they do not require aging and therefore their production can respond quickly to changes in demand. In contrast, whisky suffers from an unavoidable delay resulting from the need for maturing. This presents producers with significant challenges in their production schedules.

As we mentioned earlier, the current peak prices for rare whisky are the result of periods of massive over- and underproduction over the past 50 years. The current stock-to-sales ratio, shown in Exhibit 5, is back to the critical highs of the 1970s, and current stock levels are also at all-time highs. These are shown in Exhibit 14.

However, despite the current stock-to-sales ratio, the current level is not expected to lead to a decline in stocks, as seen in the past. The reasons lie in the good growth forecasts for Scotch whisky exports, especially to emerging markets and the Asia-Pacific region. The expanding economies of India and China offer the greatest potential here (Gordon 2020). In addition, the current low interest rate environment is

EXHIBIT 14**Maturing Whisky Stocks (aggregate of malt and grain stocks in mlpa)**

SOURCE: Bower (2016) and Gordon (2020).

significantly reducing stock costs. Moreover, for several years now the high demand for whisky has increasingly been met with non-age statement (NAS) whiskies. These bottles also contain whisky that has been stored in casks for only four to seven years. This enables producers to manage their maturing stocks more flexibly and also reduces storage costs.

These NAS whiskies also enable producers to attract new consumers. However, collectors and investors focus on rare whiskies with maturities of 16 years or more. Therefore, the current demand for old and rare whiskies cannot be satisfied with the increased production capacities and the resulting high stock levels. Of the stocks shown in Exhibit 14, almost 63% are older than three years (Gordon 2020). Further information on the age structure of stocks—such as the proportion older than 8, 12, or 16 years—is not publicly available. Against this background, it is very difficult to make statements about how the supply of old and rare whiskies, and thus also prices, will develop.

Looking at the size of the whisky market, it is comparatively small, and thus difficult for institutional investors to invest in. This applies, in particular, to investments in rare whisky bottles. The situation is different for investments in whisky casks, where the market volume is significantly larger. More than 22 million casks are currently stored in Scottish warehouses. In addition, the financing costs of the stocks for the distilleries are rising with the increased production capacities. This offers institutional investors the opportunity to invest in cooperation with the distilleries. This was demonstrated by the example of Wave Financial Group, which initiated the “Wave Kentucky Whiskey 2020 Digital Fund” together with Wilderness Trail Distillery. However, it remains to be seen whether this model has a future and whether other institutional investors will follow.

CONCLUSION

In this article, we present the price driving factors of rare whisky in a first step. We show that because whisky requires time to mature, its long product cycle makes predicting future demand, and adjusting production to fit that demand, great challenges to producers. This is reflected in the current low availability of old whiskies combined with a sharp increase in demand in recent years. Thus, the strong price increases for old whiskies within the past 10 years are primarily the result of phases of massive over- and underproduction over the past 50 years. Whether and for how long this trend will continue depends primarily on the producers' abilities to forecast future demand and adjust production to them.

We also analyzed the risk-return characteristics of rare whisky in detail and compared them with those of stocks, bonds, hedge funds, private equity, commodities, real estate, and fine wine, based on monthly data from January 2013 to December 2020. We found that the specific risk-return profile of rare whisky compared to the other asset classes qualifies rare whisky as a stand-alone asset class. Moreover, we showed that adding rare whisky to an international multi-asset portfolio leads to statistically significant performance improvements for different investment strategies. The results provide valuable insights for individual and institutional investors and allow for a better understanding of the emerging asset class of rare whisky.

Nevertheless, the importance of rare whisky's significant diversification benefits should not be overstated. Our study period covers a pure bull market due to data availability. With this in mind, further research should follow to determine if our results hold over the long term. We also showed that investments in rare whisky bottles are associated with comparatively high transaction costs. This applies, in particular, to the purchase and sale of bottles via online auctions. Against this background, further studies should follow to examine in detail the influence of transaction costs on the performance of investments in rare whisky bottles.

ACKNOWLEDGMENTS

The author would like to thank Julie Bower and Andy Simpson for providing data.

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Disclosure

No potential conflicts of interest were reported by the author.