LUNDS UNIVERSITET

School of Economics and Management

Is reaching for the whisky bottle justified?

Examining the value of whisky and its inclusion in the optimal portfolio

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**The data of whisky is collected from WhiskyAuction.com*

Glossary

Hedonic regression

A regression model used to examine what effect different explanatory variables have on the dependent variable.

Hedonic index

A price index that is based on information from the hedonic regression.

Hedonic attributes

The independent variables in a hedonic regression believed to affect the dependent variable.

Convenience yield (collectibles)

The emotional return perceived by investors owning a collectible.

Bottle age

The years the whisky has spent maturing in the cask. We refer to it as “Years_of_age” in our regression.

Year of bottling

The year the whisky was bottled after maturing. We refer to this as “Bottled” in our regression.

Hammer price

The winning bid at the auction. The price of the whisky sold at auction.

**The data of whisky is collected from WhiskyAuction.com*

Abstract

This study aims to evaluate whisky as an investment through two research questions: “What affects the value of whisky?” and “Should whisky be included in the optimal portfolio?”. The value of whisky is examined by constructing a hedonic regression using five hedonic attributes. Also, the convenience yield associated with whisky is examined. Secondly, the performance of whisky is evaluated by using portfolio theory to determine if whisky should be included in the optimal portfolio. The hedonic regression showed that the age of the bottle and the alcohol strength had a positive marginal contribution on the price of whisky. In contrast, the year of bottling had a negative impact. Additionally, when adjusting for convenience yield and transaction cost, the total return of whisky decreased slightly. A hedonic index was constructed using nine years of data to compare the return and risk of whisky with four other assets. In summary, whisky yielded higher than its peers while maintaining a lower risk. Additionally, whisky showed diversification benefits given its negative correlation with traditional assets. Finally, whisky was found to constitute the major weight in the *Minimum Variance Portfolio* (MVP) and the *Max. Sharpe Portfolio*. Thus, whisky was concluded to be part of the optimal portfolio. The study makes several contributions to the existing literature of whisky. Firstly, it addresses the concept of convenience yield on whisky. Secondly, it extends the research of whisky with regards to portfolio theory. Finally, the study covers whisky sales from over 300 distilleries, which provides a uniquely broad perspective of the Whisky market.

Keywords: Whisky, hedonic regression, convenience yield, portfolio theory

**The data of whisky is collected from WhiskyAuction.com*

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1.0 Introduction

This section introduces the reader to the paper. Firstly, the Background of the study is presented. Followed by the Problem Statement, Purpose, and Limitations.

1.1 Background

In modern society, the set of investment possibilities is enormous. The technological advancements in recent decades have rewritten the playing field for the average investor. Henceforth, the explosive increase of investment possibilities means that the opportunity set for the average investor has surged. This enables investors to diversify their portfolios by including various assets, and thus reduce the portfolio risk without giving up return. This also enables investors to broaden their understanding of which characteristics impact the value of an asset the most. Whether it is a stock, a bond, or an unconventional asset like whisky, investors can expand their knowledge of the underlying asset.

One way for investors to seek diversification is to include alternative investments in their portfolios. Alternative investments are commonly defined as illiquid assets, other than stocks, bonds, and cash. Kraussl, Lehnert, and Rinne (2017) mention hedge funds, private equity funds, real estate, and collectibles as examples of alternative investments. Thus, the possibilities of alternative investments are enormous. However, very few studies have been conducted on whisky as an alternative investment, apart from Moroz and Pecchioli (2019) and Lennon and Shohfi (2021).

To address this gap, a hedonic regression of whisky is constructed by collecting 36 385 observations of whisky bottles sold at auction from *WhiskyAuction.com.* The regression incorporates variables such as the auction date of the bottle, the age of the bottle, the year of bottling, the distillery, and the alcohol strength. The price of whisky is shown to increase by 8% for every additional year of maturation in the cask, and to decrease by 4% for every year of bottling closer to the present year. Also, the alcohol percentage is concluded to have a significant effect of 2%. Lastly, the study found that the return of whisky shrank slightly when incorporating adjustments for convenience yield and transaction cost.

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Finally, the hedonic regression is used to construct the hedonic index by incorporating month-dummies. The hedonic index stretches between 2014-2022 and enables evaluation of the returns and risk associated with whisky. The study concludes that whisky has returned 9,9% annually, thus outperforming the S&P 500 for the same period. Further analysis shows that whisky makes up most of the weight in both the *Minimum Variance Portfolio (58%)* and the *Max. Sharpe Portfolio (63%)*. This means that whisky is included in the optimal portfolio. Whisky also carries lower risk in comparison to its peers which is reflected by a lower standard deviation (6,0%). Finally, whisky correlates negatively with all included assets and thereby offers diversification benefits.

1.2 Problem Statement

Whisky as an investment remains a scarcely researched area. Although the value of whisky has been explored by both Lennon and Shohfi (2021) and Moroz and Pecchioli (2019) through construction of hedonic regressions, both studies have been limited to only examine a few distilleries or regions. Also, no studies have focused on the convenience yield of whisky. Additionally, there have been no attempts to extensively examine whisky with regards to portfolio theory. While Lennon and Shohfi (2021) examine Bourbon and demonstrate its potential to diversify portfolios and improve the rewards-to-risk ratio of traditional portfolios, the broader whisky market remains largely unexplored in this aspect.

This study aims to address these gaps by examining whisky as an investment through two research questions: “What affects the value of whisky?” and “Should whisky be included in the optimal portfolio?”. Firstly, the value of whisky is examined by assessing the impact of the hedonic attributes on the price of whisky. To accomplish this, a hedonic regression is constructed on the logarithmic price of whisky to examine the marginal effect of the hedonic attributes. The value of whisky is also examined by looking at its convenience yield, building on the framework of Dimson, Pukthuanthong, and Vorsatz (2023), and discussing its applicability to whisky. Secondly, portfolio theory is used to examine if whisky should be included in the optimal portfolio. Whisky is compared to stocks (S&P 500), gold/silver (XAU), wine (Liv-ex 100), and the US 10-year treasury bond (USGG10YR) between the

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period of 2014-2022. To conduct the performance analysis of whisky, the hedonic index is used. Furthermore, the study examines if whisky should be included in the optimal portfolio.

To deepen the understanding of the value of Whisky, the hedonic regression incorporates 325 distilleries. These include 285 distilleries in Scotland, 16 in Ireland, 8 each in Germany and Japan, 2 each in Belgium, New Zealand, and England, and 1 each in the Czech Republic and Switzerland. Also, by addressing the implications of convenience yield of whisky, the study adds a new perspective to the value of whisky by going beyond the pure financial return and focusing more on the emotional return perceived by investors. Lastly, by extensively examining whisky with regards to portfolio theory, the study builds on the findings of Lennon and Shohfi (2021).

1.3 Purpose

The purpose of this study is to identify what defines the value of whisky and further analyze its potential as an alternative investment. By characterizing the price of whisky into five elements, their individual specific effects can be examined, and so forth better explain what affects the price of whisky. The value of whisky is also discovered through the convenience yield. By examining the value of whisky, the reader is provided with additional perspectives to consider when investing in whisky. Whether it concerns the age of the bottle, the year of bottling, or the emotional return, understanding these factors is fundamental when investing in whisky.

Furthermore, the study uses the return and risk computed from the hedonic index to compare whisky with both traditional assets and other alternative investments. Thereafter, portfolio theory is utilized to determine if the inclusion of whisky in the investor's optimal portfolio is justified. The purpose of this section is to inform investors of the performance of whisky compared to traditional assets and other similar collectibles, and to conclude if whisky can offer higher risk-adjusted returns and diversification benefits to investors.

**The data of whisky is collected from WhiskyAuction.com*

1.4 Limitations

This study looks primarily at whisky bottles from the UK, the European Union, and Japan, thus excluding American whiskeys. The data is collected from one auction website only and the study is limited to nine years of data due to the scarcely available data on whisky. Also, only five hedonic attributes of whisky are examined. The only attributes which measure the production process are the alcohol strength and years of maturation in the cask (the bottle age). The dataset does not include additional variables like cask strength whisky or whether the whisky has been diluted to reach a certain alcohol strength due to the limitations of the data.

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2.0 Literature Review

The theory of diversification has long been a concept amongst investors but not until 1952 did Markowitz work on modern portfolio theory to provide a mathematical framework for diversification and portfolio optimization. His model was further expanded by Sharpe (1964), Lintner (1965), and Mossin (1965) who developed one of the pillars of modern finance, the Capital Asset Pricing Model (CAPM). These concepts have been of great interest for further studies in finding alternative investments. Many studies have been conducted to examine the performance of alternative investments, such as wine (e.g. Dimson, Rousseau, & Spaenjers, 2015; Burton & Jacobsen, 2001; Krasker, 1979), art (e.g. Mandel, 2009; Goetzmann, 1993), stamps (e.g. Dimson & Spaenjers, 2011), and Lego (e.g. Dobrynskaya & Kishilova, 2022). The conclusions from existing literature on the financial performance of these assets have been widespread. However, few studies have been conducted on whisky.

Moroz and Pecchioli (2019) analyze the characteristics of what affects the price of single malt whisky from Islay in Scotland. With a hedonic regression model, they conclude that each additional year of maturation in the cask increased the price of whisky by 8,9%. They also show that the effect on the price of whisky is positively affected by 6,7% for every additional year the whisky spends in the bottle. Thus, they conclude that whisky bottled longer ago is more expensive today.

Lennon and Shohfi (2021) explain that the market for Bourbon whisky is booming. The high demand has led to the emergence of secondary markets, which they analyze in the article. To do so, they use auction data between 2011-2019 to construct a repeat-sale index. Their data is collected from the online auction platform *WhiskyAuction.com* and a secondary marketplace, called *Strong Water Trading* (SWT). Lennon and Shohfi (2021) show that the price of Bourbon whisky has an annual yield of 9,1% over the sample period. To solidify their data, they also construct a hedonic index between the periods of 2014-2017 and between 2011-2019. Their hedonic index proves to yield an annual return between 13,1% to 18,8%. Lastly, they conclude that inclusion of Bourbon whisky in a stock and bond portfolio can improve the risk-return ratio.

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To measure the determinants of the price of whisky, Moroz and Pecchioli (2019) and Lennon and Shohfi (2021) constructed hedonic regressions. In addition, Lennon and Shohfi (2021) developed a hedonic index, as well as a repeat-sale index to measure the financial performance of Bourbon. The hedonic regression, which was first introduced by Andrew Court in 1939 (Goodman, 1998), can be used to test the effect of specific characteristics on the price. However, pure hedonic models face trouble in finding available data (Eurostat, 2013). In contrast, the repeat-sale index includes all the characteristics of an asset but assumes there is no change in the quality of an asset over time (Bailey, Muth, & Nourse, 1963). In addition, Goetzmann (1993) explains how repeat-sale indices cause selection bias problems.

Beyond the scope of financial returns, Dimson et al. (2023) prove there is an emotional dividend in holding collectibles. Dimson et al. (2023) define three subgroups of collectibles, with wine falling into the group of specialist-domain collectibles. Moreover, this enables estimation of the emotional return of whisky given the similarities between wine and whisky. In summary, the findings by Dimson et al. (2023) are examined in addition to the few available studies on the financial returns of whisky.

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3.0 Methodology & Theoretical Aspects

3.1 Data & Indices

This section describes the source used for collecting data on whisky. Emphasis is placed on explaining how the process of collecting the data has been conducted and which demarcations that have been made when collecting the data. Furthermore, the assets used in the portfolio theory are described and their relevance to the study is motivated.

The source used for collecting data on whisky is *WhiskyAuction.com*. This auction site is based in Germany and has customers from 61 countries (WhiskyAuction.com, 2023a). The auction site covers a vast part of the world and contains an exhaustive auction record of more than 470,000 sales between 2014-2023 (WhiskyAuction.com, 2023b). Furthermore, Lennon and Shohfi (2021) used *WhiskyAuction.com* to construct their hedonic regression and hedonic index, as well as their repeat-sale index. Additionally, the owners of *WhiskyAuction.com* have kindly let us use their auction data for this report.

To begin with, the sample was limited to bottles with a content quantity of 700ml. This excluded American whisky bottles from the sample, which usually contain 750ml (Lennon & Shohfi, 2021). However, given that the US only made up 7,6% of global whisky exports (WITS, 2021), and that 88% of the auction results are of 700ml bottles (WhiskyAuction.com, 2023b), the sample fairly reflects the whisky market.

Additionally, the dataset only included whisky bottles aged 15 years or older to target bottles intended for collection rather than consumption. Each observation contained the following hedonic attributes: the age of the bottle, the distillery, the auction date of the bottle, the year of bottling, and the alcohol strength. The hammer price, which is the dependent variable, was also collected for each observation. The data was collected using text analysis tools.

First, a robust sample of 21,102 observations was collected over a period of five years (2018-2022). In this way, the overall trends and patterns in the hedonic regression model could be

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tested and analyzed. The logarithmic price of whisky was regressed on the mentioned attributes, and the fit of the model to the observed data was assessed.

To further improve the fit of the model, the sample was restricted to older bottles. Thus, bottles aged 25 years or older, and 30 years or older were tested. However, since the sample was reduced drastically (see Appendix), this led to a deterioration of the model fit, which indicated that restricting the sample to older bottles did not help explaining the price of whisky better. Thus, after testing bottles aged 20 years or older for the same five-year period, it was concluded that 20 years of age fitted the model best, which meant that this subsample of whisky bottles showcased a better relationship between the included attributes and the price.

Finally, after analyzing the data and concluding that the hedonic model was best fitted by looking at whisky bottles aged 20 years or older, data of the entire available period (2014-2022) was collected. Additionally, 2,5% of the lower and higher tails in the sample were removed to prevent outliers from skewing the results. In total, 36 385 observations were collected for the nine-year period, including 325 distilleries from 9 different countries. This approach was chosen to focus on the relevant data for the entire period and to streamline the analysis from the enormous database on *WhiskyAuction.com*. The available data of 2023 was excluded for practical reasons.

The other assets which were studied in addition to whisky were stocks (S&P 500), the US 10-year treasury bond (USGG10YR), gold/silver (XAU), and wine (Liv-ex 100). Standard and Poor's 500 index represents the 500 largest publicly traded companies in the United States (S&P Global, 2023a). The index is weighted by market capitalization, which means that the larger the company is, the larger impact it has on the performance of the index (Kenton, 2023). The S&P 500 is often used as a proxy for the US stock market, since it represents a broad cross-section of the US market and has a large global impact (S&P Global, 2023b).

USGG10YR represents the rate at which the US 10-year treasury bond is sold at and is issued by the U.S government (Bloomberg Terminal, n.d). Government bonds are often considered

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risk free (Byström, 2018). Thus, the US 10-year treasury bond is adopted as the risk-free asset in this report.

Moreover, gold/silver (XAU) and fine wines (Liv-ex 100) serve as alternative investments in this report. The Liv-ex 100 represents the 100 most sought-after fine wines on the secondary market (Liv-ex, n.d). The Liv-ex 100 is an industry leading benchmark for tracking the performance of fine wine (Liv-ex, n.d). Additionally, the Liv-ex 100 was chosen since wine is the collectible which shares the most similar hedonic attributes to whisky. This is because both wine and whisky are liquid collectibles affected by their respective aging processes. Although they age differently, with wine aging in the bottle and whisky primarily aging in the cask, they still exhibit comparable traits.

The PHLX Gold and Silver index (XAU) reflects the performance of 30 gold and silver mining firms (Nasdaq, n.d). This index reflects the overall health of the gold and silver mining business. The reason for using gold and silver instead of other precious metals like copper or platinum, is primarily because of the superior history of gold and silver as a store of value (Downey, 2022). Also, gold has historically exhibited low correlation with the stock market and has served as a safe haven in times of trouble (Morgan Stanley, 2022). Silver on the other hand has historically been more affected by market downturns (Morgan Stanley, 2022).

3.2 The Value of Whisky

This section outlines the methodology and theories used to analyze the value of whisky. Firstly, the theoretical aspects and methodology associated with the hedonic regression are described. Then, convenience yield of whisky is described and how it is applied in this study.

3.2.1 The Hedonic Regression

This section begins with addressing the theoretical aspects of hedonic regressions. Then, the hedonic attributes included in the hedonic regression are explained, and why they are used in the model. The construction of the hedonic regression and the hedonic index is also explained.

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The hedonic model is a reputable method for explaining what affects the price of goods and constructing indices. It especially emphasizes the fact that goods are heterogeneous. According to Goodman (1998), the hedonic price analysis was first introduced by Andrew Court in 1939 but was then brought into vogue by Zvi Griliches in 1961. To describe the hedonic regression model, one can consider houses as an example. Houses possess different attributes, for example regarding location, size, and the year of construction (Eurostat, 2013). The hedonic regression estimates the marginal benefit that each attribute has on the price of houses (Eurostat, 2013). For this reason, the hedonic regression model is well suited for explaining the price of whisky, since whisky is a heterogeneous product that can differ widely regarding attributes such as bottle age, year of bottling, and alcohol strength. The same goes for hedonic indices, by using a hedonic index when computing the annual returns of whisky, the index accounts for the dissimilarities between different whisky bottles.

After all the data was collected, the construction of the hedonic regression was initiated. The sample was interpreted as a cross-sectional dataset, and the software used for the regression was *Gretl*. To explain the hedonic regression, the explanatory variables can be divided into four groups. Firstly, the auction date of the bottles was used to capture time effects and to show how the price of whisky evolved during different months and years. Thus, the auction date was made into month-dummies. The purpose of the month-dummies was also to construct the hedonic index later.

Secondly, the year of bottling (Bottled) was used to capture the vintage effect on the price of whisky. The year of bottling shows which year the whisky was bottled. In theory, a 20-year-old bottle of Macallan whisky remains 20 years old throughout its lifetime. However, the vintage variable measures if a 20-year-old Macallan bottled in 1990 differs in price from a 20-year-old Macallan bottled in 1991. This variable was also used by Moroz and Pecchioli (2019) to measure the vintage effect.

Thirdly, the distilleries were used to capture reputation effects associated with each distillery. The assumption that distilleries capture reputation effects is also mentioned by Moroz and Pecchioli (2019). The distilleries were made into dummies to measure the individual effect of each distillery and to conclude which distilleries produced the most expensive bottles. Also,

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creating dummies for the distilleries served as a fixed effect, to estimate the price of whisky and account more accurately for heterogeneity.

Lastly, the bottle age (Years_of_age) and the alcohol strength (Alk) were used to capture the production process of whisky. The bottle age reflects the duration of maturation in the cask, with whisky matured for 20 years in the cask frequently referred to as 20-year-old whisky. Furthermore, Aylott (2014) explains that the alcohol strength of whisky is essential when examining the production process of whisky. While Moroz and Pecchioli (2019) use several additional variables to evaluate the production process such as cask strength, coloring, and chill filtration, these attributes are not included in this study.

The price of whisky is considered to be non-stationary. Therefore, the natural logarithmic hammer price of whisky was used. Thus, the hedonic regression is a log-linear model, which is commonly used for hedonic regressions (Moroz & Pecchioli, 2019). The logarithmic hammer price was regressed on the hedonic attributes. This is illustrated in Equation 1, where Ln (hammer price) represents the logarithmic price, β_0 represent the intercept, β_1 the marginal effect of the year of bottling, β_2 the marginal effect of the bottle age, and β_3 the marginal effect of the alcohol strength. Lastly, $\sum_{t=1}^{107} \beta_t Month\ Dummy_t$ represents the month-dummies, $\sum_{d=1}^{325} \beta_d Distillery\ Dummy_d$ represents the reputation effect, and ε is the random error term.

Equation. 1: The Hedonic Regression

$$Ln(hammer\ price)_{it} = \beta_0 + \beta_1 Bottled_i + \beta_2 Years\_of\_age_i + \beta_3 Alk_i + \sum_{t=1}^{107} \beta_t Month\ Dummy_t + \sum_{d=1}^{325} \beta_d Distillery\ Dummy_d + \varepsilon_{it}$$

i = the specific bottle sold, t = the specific time period, d = the specific distillery

When running diagnostics tests to assess the reliability of the hedonic regression, the presence of heteroskedasticity could not be neglected by the Breusch-Pagan test. Therefore, robust standard errors were used to account for this. More specifically, the Eicker-White standard errors were used to account for heteroskedasticity. This adjustment helped increase the accuracy and stability of the regression.

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Furthermore, the hedonic regression was also used to construct the hedonic index, which is an integral part of the analysis. By re-using the coefficients of the month-dummies between January 2014 to December 2022 from the hedonic regression, the index was created. The month-dummies consisted of the auction month for each bottle sold. This resulted in a total of 108 month-dummies. The index was constructed by back-transforming the coefficients of the month-dummies, aiming to revert them into their original scale. Once the coefficients had been back-transformed, the index values were plotted in a graph with the index value on the Y-axis and the date on the X-axis. Lastly, a trendline was added. Thereafter, the performance analysis was initiated, which will be explained in the portfolio analysis.

3.2.2 Convenience Yield

This section introduces the concept of convenience yield, which is a subject that remains unexplored in the context of whisky. Firstly, the general concept of convenience yield is briefly explained, followed by a description of convenience yield on collectibles specifically. Lastly, the utilization of the convenience yield to whisky is explained.

Kaldor (1939), along with Working (1948), Brennan (1958), and Tesler (1958), is commonly viewed as the first to introduce the concept of convenience yield through the theory of storage, as noted by Fama & French (1987). The theory of storage addresses the discrepancy between present future prices and spot prices by looking at changes in interest, storage cost, and convenience yield (Fama & French, 1987). For the interested reader, more on this topic can be found in Fama and French (1987).

Dimson et al. (2023) elaborate on the traditional concept of convenience yield and apply it to collectibles. They show that collectibles add a sentimental value to the holder. Thus, convenience yield can also be referred to as “emotional return”. They explain that the total return of a collectible can be estimated according to Equation 2. Dimson et al. (2023) further address the implications of convenience yield on 13 specific asset classes and construct 30 return series for the chosen collectibles.

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Equation 2: The Convenience Yield of Collectibles

$$R_{t+1}^{C} = R_{t+1}^{F} + R_{t+1}^{E} - R_{t+1}^{T}$$

Where: RC = Total collectible return, RF = Financial return, RE = Emotional return or Convenience yield, RT = Transaction/holding cost

(Dimson et al., 2023)

Furthermore, Dimson et al. (2023) show that 24 of the 30 return series have positive convenience yields, where 14 of the positive return series are statistically significant at the 5% confidence level. They divide the collectibles into three separate groups: public-domain collectibles, specialist-domain collectibles, and private-domain collectibles. Public-domain collectibles include collectibles that are meant to be showcased in public settings, such as paintings and jewelry (Dimson et al., 2023). Specialist-domain collectibles compromise collectibles that are enjoyed by a condensed group of individuals that are specialized in the area (Dimson et al., 2023). They explain that the utility from owning these types of collectibles comes primarily from signaling within this group and personal amusement deriving from ownership. This group of collectibles are defined as" violins, stamps, coins, wine, and classic cars" (Dimson et al., 2023, p.6). In this study, whisky is treated as a specialist-domain collectible, mainly because whisky and wine share similar hedonic attributes. Lastly, they explain that private-domain collectibles comprise collectibles that usually are enjoyed in one's home, such as carpets and furniture, which have no signaling purpose. Instead, utility is derived from personal enjoyment (Dimson et al., 2023).

According to Dimson et al. (2023), the projected annual mean convenience yield for collectibles is 2,64%. Additionally, they estimate the average convenience yield for all specialist-domain collectibles to be 1,21% annually, and wine to have a convenience yield of 0,77%. However, they do not account for transaction costs in their estimations due to the difficulty of estimating this.

In this analysis, the transaction cost (R_{t+1}^{T}) of whisky was calculated by estimating the storage cost, insurance cost, and commision fees. Thus, the transaction cost is used as a collective term for these three components. Moreover, the commission fees were annualized by assuming a hold period in accordance with public-domain collectibles. These estimations

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were based mainly on the studies of wine, but a few modifications were made due to the different conditions for storing whisky. Also, the financial return of whisky (R^F_{t+1}) was derived from the hedonic index presented in the previous part. Lastly, the emotional return of whisky (R^E_{t+1}), was assumed to be identical to wine. In this way, the collectible return (R^C_{t+1}) in Equation 2 was calculated.

The assumption was made that the estimated collectible return (R^C_{t+1}) from Equation 2 was the same for all investors. Thus, the emotional return of whisky enthusiasts was assumed to be the same as the emotional return of the average investor. It is likely that the transaction cost and the financial return is the same for all investors. However, the primary reason for this assumption is to mitigate the confusion that would arise if some investors perceived the emotional return differently.

3.3 Portfolio Analysis

In this section, the theories of Markowitz and Sharpe are presented and how they are applied in this study. Then, a systematic description of the process of forming portfolios based on these theories is presented. Finally, the optimal portfolios used in this study are introduced. Specifically, two portfolios are examined, both considered optimal. These portfolios are the *Minimum Variance Portfolio*, and the *Max. Sharpe Portfolio*.

When discussing portfolio theory, it is essential to acknowledge the work of Markowitz (1952). He explained that it was possible to attain benefits from portfolio diversification by including different assets with different attributes and risk. He used a mathematical approach to calculate the optimal allocation between assets, where the optimal allocation gave the highest return given a certain level of risk. The calculation of the optimal allocation is based on carefully considering the return, associated risk of individual assets, and their correlations. This way, Markowitz (1952) showed that a combination of two assets with a correlation less than one could reduce the overall risk of the portfolio, without sacrificing any return.

Additionally, Sharpe (1966) proposed a risk-adjusted measure called the Sharpe ratio, shown in Equation 3. The Sharpe ratio is calculated by subtracting the risk-free rate from the

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portfolio's return, and then dividing by the standard deviation of the portfolio. By this measure, Sharpe (1966) made it possible to evaluate and compare the risk adjusted returns of portfolios and thus creating a more effective way of comparison.

The aim of the study is to show the benefits of diversification and simultaneously answer the second research question of whether whisky is part of the optimal portfolio or not. To do so, the theories of Markowitz (1952) and Sharpe (1966), are applied to evaluate and compare portfolios. Using Markowitz theories, the optimal portfolios are presented, and their expected returns and risk are measured. The Sharpe ratio will further deepen the analysis by enabling measurement of the portfolios risk adjusted returns, and thus search for the optimal risky portfolio.

Equation 3: The Sharpe Ratio

$$\text{Sharpe Ratio} = (Rp - Rf) / \sigma p$$

Where: Rp = portfolio return, Rf = risk-free rate, and σp = portfolio standard deviation

(Sharpe, 1966)

To perform a full portfolio analysis, an individual risk-return analysis of each asset was conducted. The assets examined were whisky, wine (Liv-ex 100), gold/silver (XAU), stocks (S&P 500), and the US 10-year treasury bond (USGG10YR). Whisky was examined by using the results from the hedonic index. By using the previously collected index data for each asset, the geometric annual return was calculated according to Equation 4. The geometric approach is chosen to account for compounded returns, which considers the reinvestments of returns, and presents a better estimation of the true returns.

Equation 4: The Annual Geometric Return

$$Annual\ return, r_w = \left(\frac{[initial\ value + (-)\ gains\ (losses)]}{initial\ value}\right)^{1/n} - 1$$

Where: rw = annual return, initial value = 100 (the start value of the index), n = number of years

**The data of whisky is collected from WhiskyAuction.com*

Furthermore, the annualized geometric return was used to calculate the standard deviation of each asset. Then, by using the geometric return and standard deviation, the Sharpe ratio was calculated for each asset according to Equation 3.

Secondly, to analyze if whisky should be included in the optimal portfolio, a complete portfolio analysis was constructed with the tools given by Markowitz (1952). To begin with, the individual performance measures were collected and used for this part as well. With the average annual returns, the distance to the mean was calculated for each individual year and asset, thus constructing a new table of returns. This table was used to construct the covariance matrix for the assets, which is essential for the rest of the analysis. The covariance matrix, the annualized returns, and the standard deviation were then used to construct the portfolios. Additionally, a correlation matrix of the assets was constructed, which was used to assess the relationship and the interdependence between the assets. Using a correlation matrix is considered superior when evaluating the relationship between assets, since it has better technical properties in comparison to the covariance matrix.

To construct the portfolios, some constraints were predetermined for the portfolios. Firstly, the investor had to invest all his money in stocks, therefore he could not save any money by holding cash. Secondly, the investor was prohibited from borrowing any money, therefore he could not leverage his capital. Lastly, the summation of the assets weights had to be equal to one.

With the constraints set in place the optimal portfolios were created, more specifically the *Minimum Variance Portfolio* and the *Tangency Portfolio*. The *Minimum Variance Portfolio* was calculated as it shows the combination of the chosen assets where the standard deviation is minimized (Markowitz, 1952). This portfolio will hereby be referred to as the MVP. The MVP is also of great interest as it represents the beginning of the efficient frontier (Markowitz, 1952). All portfolios from the MVP and above are considered optimal. The efficient frontier represents the portfolios which maximize the return for a given level of risk (Markowitz, 1952). In addition to the MVP, the *Tangency Portfolio* was calculated. The *Tangency Portfolio,* as suggested by its name, is tangent to the capital asset line (Markowitz, 1952). This means that for a given level of risk the investor cannot be better off than choosing

**The data of whisky is collected from WhiskyAuction.com*

the *Tangency Portfolio*. To find the *Tangency Portfolio*, one must maximize the Sharpe ratio (Sharpe, 1966), therefore this portfolio will hereby be referred to as the *Max. Sharpe Portfolio*. In combination, these two portfolios highlight the most important aspects of portfolio formation, both minimizing risk and maximizing the return given a certain level of risk.

Besides the construction of the MVP and the *Max. Sharpe Portfolio*, a random sample of 15 000 sets of portfolios were simulated. This sample represents random combinations of the chosen assets. Collectively, these portfolios will mimic the efficient frontier, which will be their only use in the analysis. The random sample is shown by gray dots in the results section. Finally, the analysis has been computed using *Microsoft Excel* in combination with the *Solver* function, to solve for the optimal portfolios.

**The data of whisky is collected from WhiskyAuction.com*

4.0 Results & Discussion

4.1 The Value of Whisky

This section consists of the results and discussion regarding the value of whisky. First, the results from the hedonic regression are presented, and the findings analyzed. Then, the same maneuver is performed for the section on convenience yield.

4.1.1 The Hedonic Regression Results

In this section, the hedonic attributes of whisky from the hedonic regression are analyzed. Also, the implications of the findings are described, and the results are discussed in relation to previous papers. The primary purpose of this section is to explain the price of whisky through the hedonic regression. Additionally, the return of whisky is also presented through the hedonic index. Although the annual return from the hedonic index is presented in this section, the analysis on the performance of whisky between 2014-2022 is conducted in the section on portfolio analysis.

Column (1) in Table 1 shows the summary results from the hedonic regression. The adjusted R-squared in Table 1 shows that the log price of whisky was explained by 77% of the included explanatory variables. This is regarded as a satisfying adjusted R-squared given the difficulties of finding data on whisky. The degree of fit between the model and the data is in line with Moroz and Pecchioli (2019) who presented a R-squared of 77,6%. Lastly, all the quantitative variables proved to be significant at the 1% level.

**The data of whisky is collected from WhiskyAuction.com*

Table 1: Hedonic Regression Results

The hedonic index was constructed by regressing the logarithmic hammer price of whisky on the year of bottling (Bottled), the age of the bottle (Years_of_age), the distillery (Distillery dummies), the auction month (Month dummies), and the alcohol strength (Alk). However, the independent variables of distilleries and auction date were made into dummies to differentiate the time specific effects but also the individual effects of the distilleries. It should be highlighted that the month dummy for period 0 (the start month) was removed to avoid multicollinearity. Standard errors are reported below the coefficients. Also, the significance level is highlighted with *, **, *** to address the level of significance at the 0.1, 0.05 and 0.01 level. Finally robust standard errors (HC1) were used to account for heteroskedasticity. The data used to complete the regression was gathered from WhiskyAuction.com.

	(1)
Constant	91,93***
	(0,85)
Bottled	-0,04***
	(0,00)
Years_of_age	0,08***
	(0,00)
Alk	0,02***
	(0,00)
Month Dummies	Yes
Distillery Dummies	Yes
N	36 385
R-squared	0,77

The year of bottling (Bottled), which was set out to capture the vintage effect, showed to have a negative effect on the price. Table 1 shows that Whisky bottled one year closer to the present year decreased by 4% in price. Conversely, whisky bottled one year further from the present year increased by 4% (See Appendix). Thus, a 20-year-old Macallan bottled in 1990 will be 4% more expensive than a 20-year-old Macallan bottled in 1991 (all else equal). Moroz and Pecchioli (2019) concluded this effect to be 6,7%. Regardless, the effect of 4% aligns with the expectations since whisky produced longer ago naturally becomes rarer as time goes by, mainly because it is consumed and the supply decreases. Unlike wine, the

**The data of whisky is collected from WhiskyAuction.com*

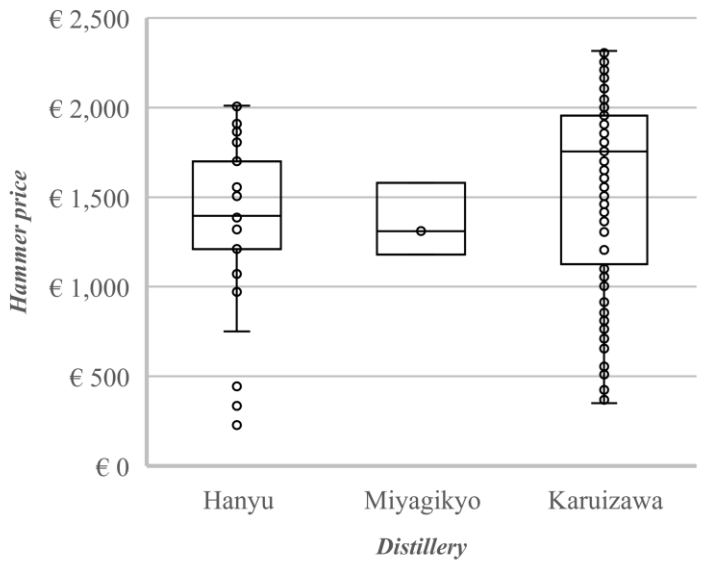
intrinsic characteristics (referring to the flavor) of whisky does not change with time (Moroz & Pecchioli, 2019). Thus, while wine becomes more expensive with time, this effect is also due to the change of its intrinsic characteristics, as noted by Dimson et al. (2015). Therefore, the higher price of whisky bottled longer ago primarily lies in the decreasing supply of old bottles, which enhances its value as a collectible, rather than any intrinsic changes of its character.

Regarding the distilleries, 215 distilleries were significant at the 1% level, 249 distilleries were significant at the 5% level, and 264 distilleries were significant at the 10% level. The reputation effect seems to have the largest impact on Japanese distilleries. Figure 1 shows that the three Japanese distilleries *Hanyu, Miyagikyo, and Karuizawa* had the highest average hammer prices out of all 325 distilleries. Compared to the average sample price of 211€, *Hanyu* whiskeys had an average price of 1352€, *Miyagikyo* whisky averaged 1357€, and whisky from *Karuizawa* averaged 1577€. The *Hanyu* distillery has a rich history dating back to the 17th century but was shut down in the early 2000s (Master of Malt, n.d). The combination of its rich history and the closing of the distillery likely explains the hefty price tags on their bottles. Regarding *Miyagikyo*, the reason for their pricey bottles is likely because they are so infrequently traded, with only 3 observed sales over 9 years. Karuizawa, which is deemed the most reputable distillery, was also closed in the early 2000s, and was known for being located next to an active volcano (Uisuki, n.d). Thus, the reputation effect seems to be greatest for distilleries with either a unique history, a distinctive edge, or infrequently traded bottles.

**The data of whisky is collected from WhiskyAuction.com*

Figure 1: A Boxplot of the Three Distilleries with the Highest Average Price

A box plot of the three most reputable distilleries in the sample. Starting from Hanyu, Miyagikyo, and finally Karuizawa. On the y-axis the hammer price is presented. Note that the total amount of observation differs largely between the distilleries. Hanyu is explained by 35 observations, Miyagikyo 3 observations, and Karuizawa with 241 observations. The reputation effect for all three distilleries proved significant at the 1% level. The data used to construct the figure was gathered from WhiskyAuction.com.



The variables set out to capture the production process were the bottle age (Years_of _age) and the alcohol strength (Alk). Table 1 shows that there is a positive effect of 8% on the price of whisky when it is aged in the cask (Years_of _age). This means that maturing whisky for one additional year in the cask increases the price by 8% (See appendix). Thus, a 20-year-old Macallan whisky bottle is, all else equal, 8% more expensive than a 19-year-old Macallan. Moroz and Pecchioli (2019) concluded this effect to be 8,9%. This result was also in line with the expectations, since whisky matured for a longer period naturally becomes more expensive. This is because the distilleries incur higher production costs, which they transfer to the consumers through higher bottle prices.

Furthermore, Table 1 shows that there is a marginal contribution of 2% of the alcohol strength on the price of whisky. Thus, stronger whisky tends to be more expensive. Moroz and Pecchioli (2019) explain that cask strength whisky, referring to whisky bottled directly from the cask, tends to be stronger compared to diluted whisky. Thus, whisky included in the sample of this study which has higher alcohol strength is likely cask strength whisky. Cask

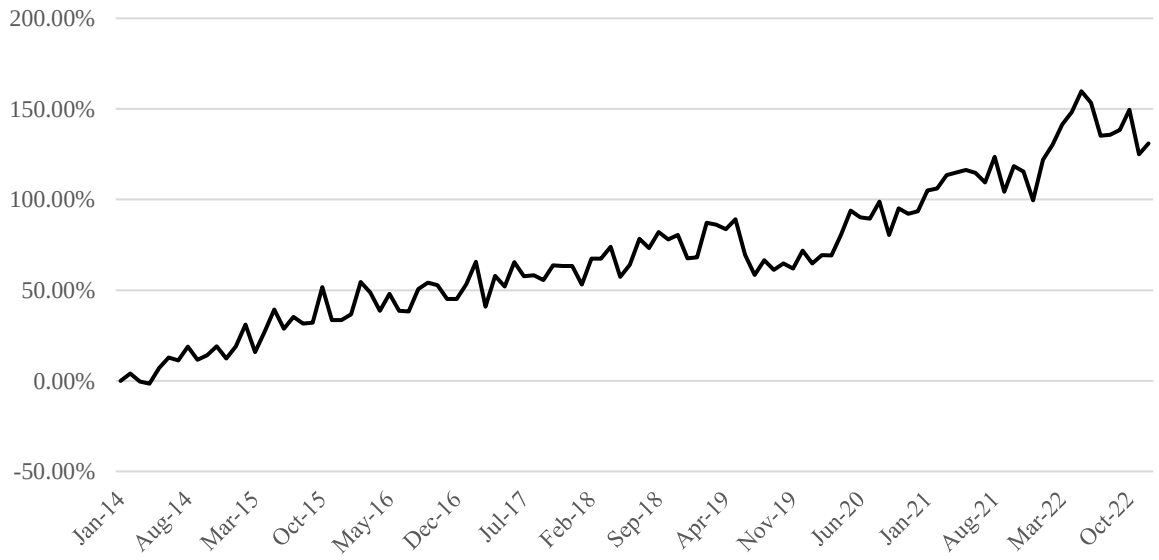
**The data of whisky is collected from WhiskyAuction.com*

strength whisky is expected to be 56,2% more expensive than diluted whisky (Moroz & Pecchioli, 2019). While the study was unable to capture the effect of cask strength whisky specifically, which is a limitation, it is likely that the alcohol strength partly captures this effect.

Lastly, the month-dummies captured the time effects effectively which enabled the construction of the hedonic index presented in Figure 2. The hedonic index of whisky shows a total return of 131% between 2014-2022, equivalent to an annual geometric return of 9,9%. This indicates that on average, there is a positive time effect on the price of whisky on a yearly basis. However, evaluating the time effect between months, the volatility seems to increase. In summary, while the prices of whisky tend to fluctuate a lot during the year, the overall temporal effect is significantly positive.

Figure 2: The Hedonic Index of Whisky

The hedonic index of whisky is presented in a time weighted monthly returns index. The returns are also in nominal terms. The index was created using a hedonic regression approach, capturing the monthly time effects on the price of whisky. The starting period is the first of January 2014, and the final date is the last of December 2022. The index is not adjusted for transaction, inventory, or storage cost of whisky. The data used to complete the index was gathered from WhiskyAuction.com.



In summary, this section highlights various hedonic attributes and how they impact the value of whisky. From the hedonic regression it was concluded that the value of whisky is

**The data of whisky is collected from WhiskyAuction.com*

negatively affected by the year of bottling (-4%), suggesting that whisky bottled closer to the present year is priced lower. Additionally, the bottle age affected the price positively by 8%, indicating that whisky matured longer is valued higher. The alcohol strength affected the price positively by 2% which suggests that stronger bottles are more expensive. Also, the Japanese distilleries seem to be the most reputable ones in the sample. Finally, the annual temporal effect was shown to be 9,9%, which indicates that the year of sale is of great importance.

4.1.2 Convenience Yield

In this section, the impact of convenience yield on whisky is explored. Likewise, the transaction cost is discussed. This section contributes to the discussion on the value of whisky by introducing perspectives that may not be immediately considered by investors seeking to invest in whisky.

When determining whether investing in whisky is justified, one needs to account for the convenience yield associated with owning whisky. Since whisky is regarded as a specialist-domain collectible, the findings of Dimson et al. (2023) can be applied to whisky as well. And given the similarities between whisky and wine, the assumption that the emotional return is the same for the two assets is sensible. Thus, the emotional return for whisky (R_{t+1}^{E}) in Equation 2 is assumed to be 0,77%.

Furthermore, investing in whisky implies a transaction cost that needs to be accounted for. Dimson et al. (2015) estimate the storage cost of Wine to be around 0,23%. Thus, since it was concluded that whisky and wine share enough similarities to justify a comparison between the two, it is reasonable to assume that storing whisky incurs a somewhat similar cost. However, it is also sensible to assume that the cost of storing whisky is even lesser. This conclusion is derived from the fact that storing whisky does not require a wine cooler or a wine cellar. Whisky only requires to be stored in room temperature (15-18 degrees Celsius), kept away from the sunlight and with little fluctuation in temperature (Macallan, 2019). Hence, assuming the storage cost of whisky to be zero is justifiable, and therefore no adjustments are made for the storage cost in the estimation of the total transaction cost. Regarding the

**The data of whisky is collected from WhiskyAuction.com*

insurance cost of whisky, it is defensible to assume the same cost incurred for wine, which Dimson et al. (2015) assumed to be 0,5%.

Additionally, one needs to account for the commission fees associated with buying or selling whisky. *WhiskyAuction.com* charges 10% of the hammer price, both on the seller and the buyer (WhiskyAuction.com, 2023c). This seems to be similar to commission fees charged on other whisky auction sites such as *Whiskyshop.com* and *WhiskyAuctioneer.com*. The commission fees for whisky also seem to be in line with the fees of collectibles assumed by Dimson et al. (2023). They stress that the seller's fees can be as high as 20-30% in some auction houses, but that 10% is usually regarded as reasonable. Moreover, to determine what the hold period of whisky should be, the hold period of art is utilized, which was concluded to be 28 years by Mei and Moses (2002). Although art is believed to be a public-domain collectible according to Dimson et.al (2023), the lack of information on the hold period of specialist-domain collectibles leads to this assumption. Considering the commission fees both for entering and exiting the whisky market, investors face a total fee of 20%. However, if the hold period is assumed to be 28 years, this commission fee can be spread out annually over the period, resulting in an annualized fee of 0,71%. By adding together, the insurance cost and the annualized commission fee, the total transaction cost of whisky (R_{t+1}^{T}) amounts to 1,21% (0,5% + 0,71%).

Now, if the estimated financial collectible return (R_{t+1}^{F}) of 9,9% (obtained from the hedonic index) is tied together with the emotional return (R_{t+1}^{E}) of 0,77% , and the total transaction cost (R_{t+1}^{T}) of 1,21%, the total collectible return described in Equation 2 can be calculated. With this simplified approach, a total collectible return (R_{t+1}^{C}) of 9,46% is derived.

Thus, there are various aspects that affect the investment in whisky, some more obvious than others. The transaction cost might be the most obvious one and is likely something most investors consider regardless of which asset they acquire. The commission fees for whisky are seemingly large in contrast to other traditional assets, and this holds true for collectibles in general, as pointed out by Dimson and Spaenjers (2011). However, the effect is reduced when assuming the hold period of whisky to be in line with public-domain collectibles.

**The data of whisky is collected from WhiskyAuction.com*

The emotional return might be the less obvious aspect. Nevertheless, it is an important aspect to understand when examining why investing in whisky is compelling to some people. Although the emotional return is assumed to be the same for all investors to draw any conclusions from Equation 2, this is likely not the case. It is evident that people with a passion for whisky receive higher emotional return from owning whisky, primarily from signaling and personal enjoyment, and this is not reflected in a traditional index like the hedonic index. Likewise, this means that investors with no interest in whisky, other than the pure financial gains, will not receive an emotional return. The average investor is more likely to solely account for the transaction cost, which is less abstract to an investor outside the condensed group of whisky enthusiasts.

In conclusion, although the value of whisky often circles around the attributes of the bottle like the bottle-age or the distillery name, there are also additional factors that investors need to incorporate in their investment decisions. When adjusting the return by accounting for more abstract factors like the emotional return, and more concrete factors like transaction cost, the collectible return derived from Equation 2 decreases by 0,44% compared to the return from the hedonic index.

4.2 Portfolio Analysis

This part will broaden the understanding of the return and risks of whisky. Firstly, the individual performance of whisky, stocks (S&P 500), wine (Liv-ex 100), gold/silver (XAU), and the US 10-year treasury bond (USGG10YR) is presented and commented on. Then, the portfolio analysis is presented, first graphically, and then in a table. The portfolio theory consists of constructing the optimal portfolio, which consists of two portfolios: the *Minimum Variance Portfolio* (MVP) and the *Max. Sharpe* Portfolio. Thereafter, emphasis is placed on discussing the standard deviation of whisky and how this could affect the results in the portfolio theory. Lastly, a correlation matrix is presented and the implications of the negative correlation of whisky to other assets is discussed.

**The data of whisky is collected from WhiskyAuction.com*

Table 2 shows the annual geometric return of each asset individually between 2014-2022. Whisky had the highest return of 9,9%, closely followed by the stock market which returned 9,7%. Furthermore, gold/silver returned 4,9%, wine returned 6,1%, and the US 10-year treasury bond returned 2,1%. Table 2 also shows that the standard deviation was 6,0% for whisky, 11,1% for stocks, 10,8% for gold/silver, followed by 10,9% for wine. The Sharpe ratio was clearly highest for whisky (1,3), and stocks claimed second place with a Sharpe ratio of 0,7. Lastly, Table 2 shows that the lowest Sharpe ratios were those of wine (0,4), and gold/silver (0,3). Since whisky has the highest annual return and the lowest annual standard deviation, whisky also has the highest Sharpe ratio. This simply means that if one had to choose to invest in one asset only, the choice would naturally fall on whisky.

Table 2: Performance Measurements of Assets

The table shows the geometric returns for the assets in nominal terms over the period of 2014-2022. In addition, the annual standard deviation is shown, as well as the Sharpe ratio. The data used to measure the performances of the assets other than whisky were collected exclusively from Bloomberg Terminal. The data collected for whisky was gathered from WhiksyAuction.com.

Asset	*Annual Geometric Return*	*Standard Deviation*	*Sharpe ratio*
Whisky	9,9 %	6,0 %	1,3
Stocks (S&P 500)	9,7 %	11,1 %	0,7
Gold/silver (XAU)	4,9 %	10,8 %	0,3
Wine (Liv-ex 100)	6,1 %	10,9 %	0,4
USGG10YR (Rf)	2,1%	-	-

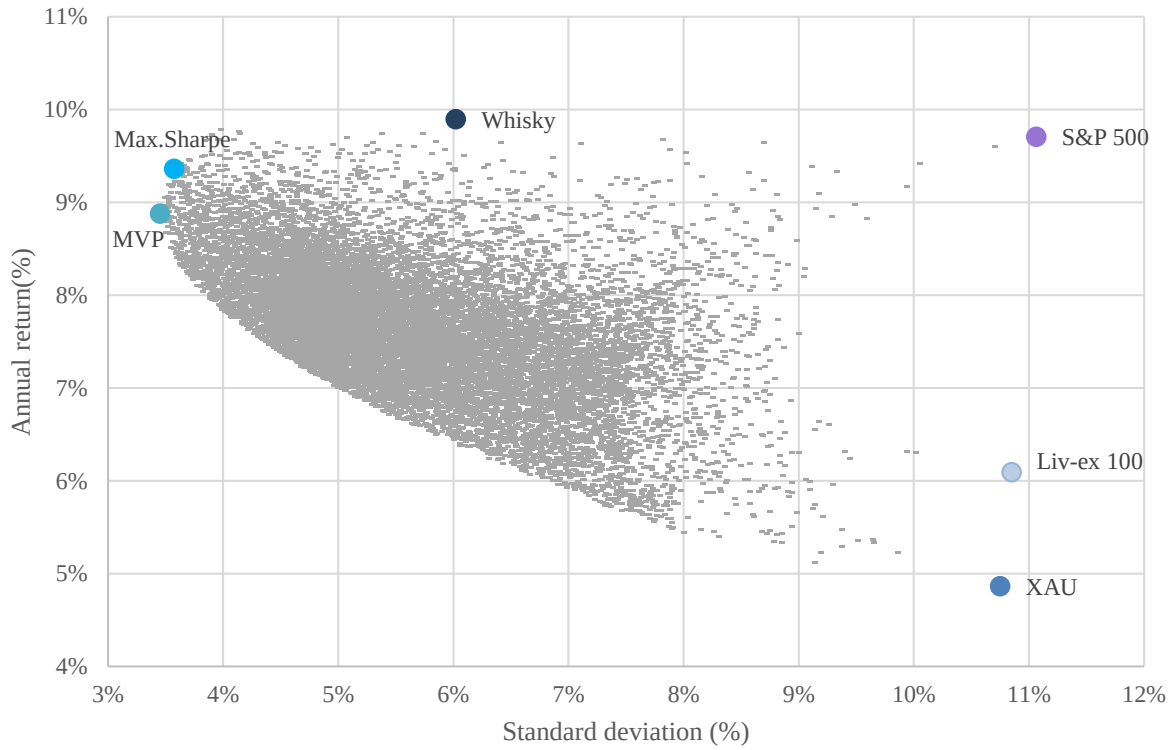
However, evaluating the assets individually is not the primary purpose of this section. The primary purpose is instead to examine the assets within the framework of modern portfolio theory, where the assets are combined into different portfolios. For this part the same assets as in the previous part were used. Figure 3 shows the results from the construction of the optimal portfolios. The first optimal portfolio is the *Max. Sharpe Portfolio*, also known as the *Tangency Portfolio*, which maximizes the return for a given level of risk. Figure 3, together with Table 3, shows that the *Max. Sharpe Portfolio* returns 9,4% annually with a standard deviation of 3,6%. The other optimal portfolio is the *Minimum Variance Portfolio* (MVP)

**The data of whisky is collected from WhiskyAuction.com*

which minimizes the level of risk given the set of assets. The MVP returned 8,9% with a risk of 3,5%.

Figure 3: The Efficient Frontier

The figure Shows the assets average standard deviation (x-axis) in comparison to their annual geometric return (y-axis). The visible portfolios are the individual assets of whisky, S&P 500, gold/silver, and Liv-ex 100, as well as the *Minimum Variance Portfolio* (MVP) and the *Max. Sharpe Portfolio (Tangency Portfolio).* In addition, a sample of 15 000 random sets of portfolios are showcased as the shaded gray area. These 15 000 random sets of portfolios give rise to the efficient frontier. The annual returns were calculated geometrically. The data used to measure the performances of the assets other than whisky were collected exclusively from Bloomberg Terminal. The data collected for whisky was gathered from WhiksyAuction.com.



Furthermore, Table 3 shows the MVP, the *Max. Sharpe Portfolio*, and the *Max. E[r] Portfolio* which maximizes the return without accounting for risk. The MVP is weighted with 58% whisky, 19% stocks, 10% gold/silver, and 13% wine. The Sharpe ratio of the MVP is 1,96. In comparison, the *Max. Sharpe Portfolio* is weighted 63% whisky, 25% stocks, 3% gold/silver, and 9% wine, as shown by Table 3. The Sharpe ratio of this portfolio is an impressive 2,03. Also, Table 3 shows that the *Max. E[r] Portfolio* is exclusively made up of whisky which demonstrates the astounding performance of whisky.

**The data of whisky is collected from WhiskyAuction.com*

Table 3: Optimal Portfolios

The table showcases the different sets of optimal portfolios, starting with the *Minimum Variance Portfolio* (MVP), followed by the *Max. Sharpe portfolio,* and lastly the *Maximum Expected return portfolio (Max. E[r]).* The different weights of the portfolios are shown in the bottom part of the table. The weights of the specific assets are shown in percentages (%). The portfolios were constructed with the restriction that the total sum of weights would equal 100 %, thus not allowing for borrowing (leveraging) nor saving (holding cash). The data used to measure the performances of the assets other than whisky were collected exclusively from Bloomberg Terminal. The data collected for whisky was gathered from WhiskyAuction.com.

Portfolios	*MVP*	*Max. Sharpe*	*Max E[r]*
E[r]	8,9 %	9,4 %	9,9%
SD	3,5 %	3,6%	6,0
Sharpe	1,96	2,03	1,3
	Weights		
Whisky	58%	63%	100%
Stocks (S&P 500)	19%	25%	0%
Gold/silver (XAU)	10%	3%	0%
Wine (Liv-ex 100)	13%	9%	0%

It is evident that whisky is a desirable asset in an investor's portfolio. Whisky constitutes the lion's share of the weight in both the MVP and the *Max. Sharpe Portfolio*. Thus, investing in whisky is justified when evaluated within the framework of modern portfolio theory. However, it must also be acknowledged that the standard deviation for whisky as a stand-alone asset is lower than all the other assets included. Although whisky and stocks returned similarly, whisky still makes up more than half of both the MVP and the *Max. Sharpe Portfolio*, and the reason for this is partly the lower standard deviation. Thus, since the standard deviation has such a decisive impact on the results in the portfolio theory, it is sensible to examine the standard deviation of whisky closer.

Given the similarities between whisky and wine, it would be reasonable to believe that the two assets would exhibit similar standard deviations. This is because they are both collectibles containing liquid content that are traded on illiquid markets. A common feature for illiquid markets is the appearance of autocorrelation (Dimson et al., 2023). Dimson et al. (2023) explain that the lack of transactions of collectibles leads to autocorrelation in the returns, which is manifested as a smooth index of returns. The result from this is underestimation of the true variance (Andersen, Gökhan, & Nikolaus, 2017), and misestimation of the covariance (Scholes & Williams, 1977; Dimson, 1979). This could be one possible explanation as to why

**The data of whisky is collected from WhiskyAuction.com*

the standard deviation is lower for whisky, and why whisky has such a large weight in the optimal portfolios.

In contrast to the low standard deviation of whisky, it is important to consider its negative correlation to the other assets. Table 4 highlights the correlation of whisky to other assets, starting with stocks (-0,47), gold/silver (-0,26), and wine (-0,18). As proven by the table, the correlation between whisky and all assets is negative. This means that combining a portfolio of whisky with any asset would lower the total risk significantly compared to investing in only one of them, as proven by Markowitz (1952). Furthermore, Table 4 shows that stocks and gold/silver share a correlation of 0,37, followed by stocks and wine with a correlation of 0,11. Lastly, gold/silver and wine have a correlation of 0,09. The great weight of whisky in the optimal portfolios can so forth not only be explained by its low standard deviation but also by its negative correlation to the other assets, thus making it an effective investment alternative for diversification.

Table 4: Correlation Matrix

The table highlights the correlations between the different assets. Starting with Whisky to Whisky in the upper left-hand corner ending with Liv-ex 100 to Liv-ex 100 in the lower right-hand corner. The data used to measure the performances of the assets other than whisky were collected exclusively from Bloomberg Terminal. The data collected for whisky was gathered from WhiskyAuction.com.

	Whisky	Stocks (S&P 500)	Gold/silver (XAU)	Wine (Liv-ex 100)
Whisky	1,0			
Stocks (S&P 500)	-0,47	1,0		
Gold/silver (XAU)	-0,26	0,37	1,0	
Wine (Liv-ex 100)	-0,18	0,11	0,09	1,0

**The data of whisky is collected from WhiskyAuction.com*

In conclusion, whisky offers significant returns to a relatively low risk. Therefore, whisky makes up the lion's share in both the *Minimum Variance Portfolio* and the *Max. Sharpe Portfolio*, with a weight of 58% and 63% respectively. In addition, whisky appears to have negative correlation with the other assets, which further strengthens the incentive for diversifying portfolios with whisky. However, one must also acknowledge the presence of illiquidity on the whisky market which may influence the standard deviation, thus undermining the true risk. Despite this, the inclusion of whisky in the optimal portfolio is deemed justifiable.

**The data of whisky is collected from WhiskyAuction.com*

5.0 Conclusion & Future Research

5.1 Conclusion

The study explored whether investing in whisky is justified by analyzing an original dataset consisting of 36 385 observations between 2014-2022. To investigate this, the study was divided into two sections: the value of whisky and the portfolio analysis. These two components were used to better understand what affects the price of whisky and to evaluate if whisky should be included in the optimal portfolio.

A hedonic regression was constructed by including the bottle age, the year of bottling, the alcohol strength, the auction date, and the distilleries. Through the hedonic regression, it was possible to examine what affects the price of whisky. The conclusion drawn from the first section was that the age of the bottle (Years_of_age) had a marginal contribution of 8% on the price, the year of bottling (Bottled) contributed with -4%, and the alcohol strength (Alk) with 2%. Finally, the Japanese distilleries proved to be the most reputable ones. The study also delved deeper into the convenience yield of whisky. The collectible return of whisky was adjusted by accounting for the convenience yield and the transaction cost. The study concluded that the adjusted return shrank slightly (-0,44%) compared to the return from the hedonic index.

In the portfolio analysis, the aim was to conclude if investing in whisky is justified. A hedonic index was constructed by re-using the month-dummies between 2014-2022 and the annual geometric return of 9,9% was computed. The return of whisky was compared to stocks (S&P 500), gold/silver (XAU), wine (Liv-ex 100), and the US 10-year treasury bond (USGG10YR). Additionally, two optimal portfolios were constructed, the *Minimum Variance Portfolio* and the *Max. Sharpe Portfolio*. The results showed that Whisky had most of the weight in both portfolios. Thus, whisky was concluded to be included in the optimal portfolio.

**The data of whisky is collected from WhiskyAuction.com*

5.2 Future Research

In this study, the variables that captured reputation effects (distillery names), temporal effects (the auction date), and vintage effects (year of bottling) were in focus. However, too little emphasis was placed on the production process of whisky and its effects on the price. The only variables capturing the production process were the alcohol strength (Alk) and the maturation in the cask (Years_of_age). It would therefore be of interest to dig deeper into the production process of whisky and capture this effect on the price. This could be done by including variables such as which type of cask the whisky has matured in, or if the whisky has been matured in several different casks Also, variables such as cask strength, chill filtration, and coloring could be used to better explain the production process, as done by Moroz and Pecchioli (2019). This would make the hedonic regression more comprehensive. However, the limitations of including variables to account for this lies primarily in the data.

Furthermore, the estimation of the emotional return of whisky could be derived in a more original manner, instead of comparing whisky to wine. This could be done by taking the same approach as Dimson et al. (2023). Although the complexity behind the estimations of the convenience yield on collectibles requires a relatively advanced academic background, it could be of interest for future studies on the topic.

Finally, it would be deeply interesting to extend the time span of the study to cover at least one additional decade. After all, nine years is not a very long period, and the return of whisky might be different if the period was extended. It would be interesting to examine the performance of whisky during several economic downturns. The current timespan only includes the brief market downturn during the *Covid-19 Pandemic*. Thus, it would be interesting to study the performance of whisky during the *Subprime Crisis* in 2007 and the *Dot-com Bubble* in the early 2000s to see if whisky withholds its attractive diversification benefits.

**The data of whisky is collected from WhiskyAuction.com*

6.0 References

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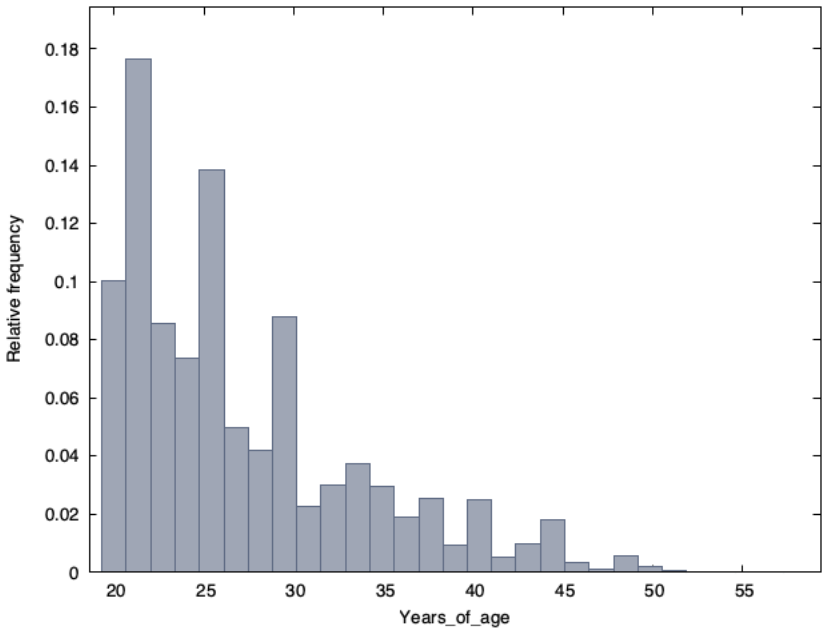
7.0 Appendix

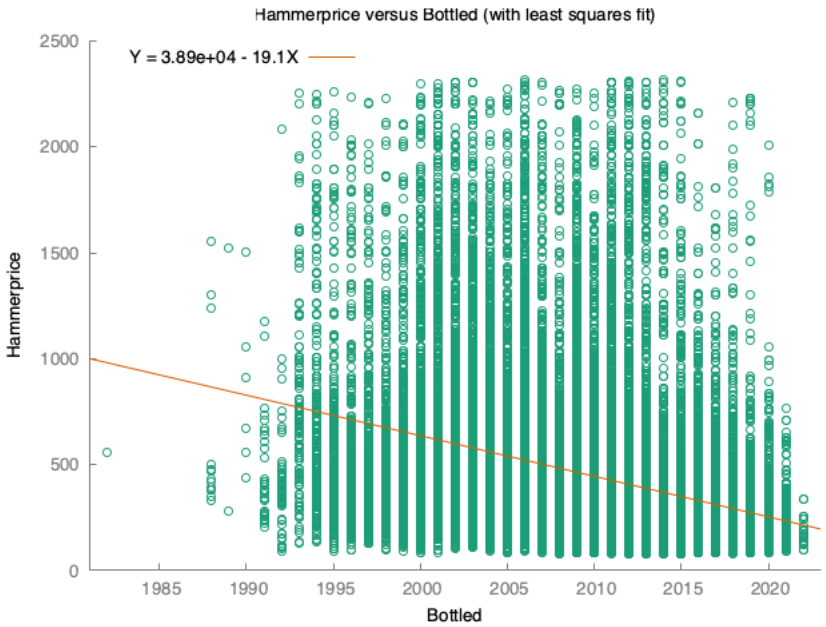
Frequency distribution of Years_of_age

The figure provides a distribution of the whisky bottle age in the full sample. Starting from bottles aged 20 years till the last observation at 58 years old.



Year of bottling in comparison with hammer price

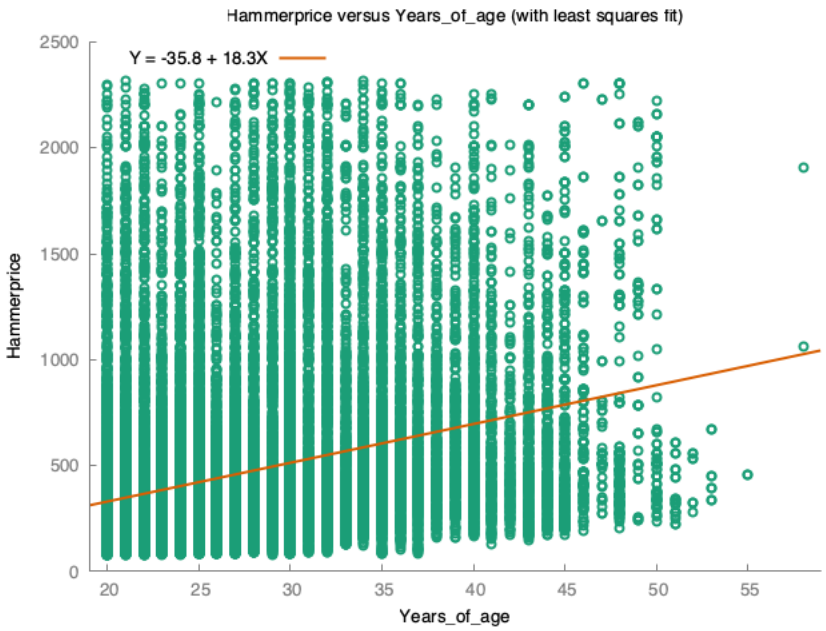
A plotted graph of the bottled year on the x-axis and the hammer price on the y-axis for the full sample. The sample stretches from 1982 till 2022.



**The data of whisky is collected from WhiskyAuction.com*

Bottle age in comparison with hammer price

A plotted graph of the bottle age on the x-axis and the hammer price on the y-axis for the full sample. The sample stretches from 20 years till the last observation at 58 years old.



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