UNIVERSITY OF VAASA

SCHOOL OF ACCOUNTING AND FINANCE

Jari Sara

FINE WINE AS AN INVESTMENT: THE RISK-ADJUSTED PROFITABILITY AND THE ROLE IN PORTFOLIO DIVERSIFICATION

Master's Thesis in
Accounting and Finance

VAASA 2019

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

ABBREVIATIONS

ADF	Augmented Dickey-Fuller unit root test
CAL	Capital Allocation Line
CAPM	Capital Asset Pricing Model
CMA	Conservative Minus Aggressive
CPI	Consumer Price Index
CTE	Conditional tail expectation
ES	Expected Shortfall
FTSE	Financial Times Stock Exchange
HML	High Minus Low
LIBOR	London Interbank Offered Rate
Liv-ex	London International Vintners Exchange
LPSD	Lower Partial Standard Deviation
MPT	Modern Portfolio Theory
MSCI	Morgan Stanley Capital International
NAV	Net Asset Value
OLS	Ordinary Least Squares
RMW	Robust Minus Weak
SMB	Small Minus Big
S&P	Standard & Poor’s
T-bills	Treasury
VaR	Value at risk

UNIVERSITY OF VAASA
School of Accounting and Finance
Author: Jari Sara
Topic of the thesis: Fine Wine as an Investment: The Risk-Adjusted Profitability and the Role in Portfolio Diversification
Degree: Master of Science in Economics and Business Administration
Master's Programme: Finance
Supervisor: Janne Äijö
Year of entering the University: 2017
Year of completing the thesis: 2019 **Number of pages: 67**

ABSTRACT

The purpose of this thesis is to examine the return characteristics of fine wine as an investment and the role of fine wine in portfolio diversification. Investors seek investment opportunities, which can increase portfolio performance. As alternative investments, such as fine wine, can be uncorrelated with traditional assets, it is necessary to study fine wine as an investment and the potential diversification benefits of including fine wine in a portfolio. The empirical research is conducted by comparing the risk-adjusted performance of fine wine to stocks, bonds and gold with 4 performance measures: Sharpe ratio, Sortino ratio, value at risk and expected shortfall. The role in portfolio diversification is first tested with inflation hedging properties of fine wine, which is tested with linear regression models, and lastly the traditional mean-variance framework is deployed for obtaining the optimal portfolio. The total sample consist of 3710 monthly observations over a time period from January 1988 to December 2018.

On average, in inflation-adjusted terms, the average annual return for fine wine is 5.60%, which the second highest real return after mid cap U.S. stocks with 6.55% return. The results suggest that on a risk-adjusted basis, fine wine is the second most profitable investment after bonds, which has lower standard deviation of returns compared to other asset classes. Compared to stocks, fine wine is more profitable in all performance measures, except for Sharpe ratio, where mid cap U.S. stocks are more profitable.

In terms of portfolio diversification, for inflation hedging, fine wine and gold show evidence of inflation hedging properties. Fine wine seems to hedge both against expected and unexpected inflation, and the results are statistically significant at 1% level. Moreover, fine wine investments in a portfolio increases portfolio performance, since the efficient frontier with fine wine investments is higher compared to portfolio without fine wine, which results in a steeper capital allocation line. The optimal portfolio with fine wine consists of bonds (74.47%), fine wine (15.60%) and mid cap U.S. stocks (9.93%) and the Sharpe ratio for this portfolio is 0.78, when the Sharpe ratio for optimal portfolio without fine wine is 0.72.

The results indicate that fine wine could be beneficial for portfolio diversification due to low correlation with traditional asset classes and lower standard deviation compared to stocks. The information presented in this study provide information to individual and institutional investors on how alternative investments can increase portfolio performance.

KEY WORDS: Fine wine investment, profitability, inflation hedging, portfolio optimization

1 INTRODUCTION

Investors constantly seek investment opportunities, which can provide utility in terms of diversification to their portfolio. Since financial crisis in 2008, the stock market has been bullish through 2010s. However, low interest rates and the uncertainty, when the next crisis will hit the stock market, forces investors to consider what is the optimal portfolio allocation between different asset classes. Especially, investors are seeking assets with negative or low correlation with traditional assets, in order to maximize the diversification benefit. Since Markowitz (1952), investors have been aware of the benefits of adding assets to the investment portfolio.

Wine is an alcoholic beverage commonly used for consumption only. However, by the decreasing supply through consumption and the increasing demand for top quality wines, especially in the emerging markets, the prices for fine wine has increased. Therefore, since the high-quality wines can be stored for decades, fine wine also possesses characteristics, which allow it to be considered as an alternative investment asset, similar to collectibles, such as art or stamps. With an increasing need for hedging the portfolio against stock market downturns and rising interest rates, alternative investments, such as fine wine, could have a valuable role in portfolio diversification. Thus, it is necessary to study the characteristics of fine wine as an investment and the role fine wine can have in an investment portfolio.

1.1 Purpose of the thesis

The amount of previous studies regarding fine wine as an investment is relatively small. Specifically, the risk-adjusted performance measurement is usually restricted to Sharpe ratio, which uses standard deviation of returns as the measure for risk. The purpose of this study is to analyse the risk-adjusted returns of fine wine using multiple risk-adjusted performance measures in addition to Sharpe ratio to gain more comprehensive insight to fine wine as an investment. Further, the returns of fine wine are compared to common asset classes such as stocks, bonds and gold over a period of 1988 – 2018.

As wine can be seen as a commodity, the second main objective is to investigate if fine wine investments can bring utility to investors as a hedge against inflation. Lastly, the third goal is to find the optimal investment portfolio which invest in stocks, bonds, gold and fine wine. The emphasis is in finding the role fine wine can have in a portfolio in terms of diversification and to examine the portfolio performance with fine wine investments.

1.2 Research hypotheses

Fine wine as an investment asset are examined by forming three research hypotheses. The first hypothesis is defined based on the study by Masset & Weisskopf (2010a), who study auction hammer prices by constructing indices for various wine regions over the period 1996 – 2009. The authors suggest that wine investments are more profitable by providing higher returns with lower volatility compared to U.S. and international stocks. As this study examines also bond and gold investments, the first hypothesis is following:

> H1: The risk-adjusted returns of fine wine investments outperform stock, bond and gold investments.

Commodities can be good inflation hedges (see Erb & Campbell 2006; Gorton & Rouwenhorst 2006). Therefore, as wine can be regarded as an agricultural commodity, fine wine investments could provide hedge against inflation. Thus, the second hypothesis is stated as follows:

> H2: Wine investments provide hedge against inflation.

Aytaç, Thi-Hong-Van & Mandou (2016) argue that fine wine can provide diversification benefits in a portfolio and the performance of the portfolio increases when the amount of wine in the portfolio increases. Hence, the third hypothesis supports the claim of Aytaç et al. (2016):

H3: Wine investments in a portfolio increase portfolio performance.

1.3 Contribution

This thesis contributes to the existing literature by providing updated information on fine wine as investment. In terms of risk, previous research papers mostly use Sharpe ratio only as a measure of risk-adjusted return. The analysis is extended to include several risk-adjusted performance measures to achieve a more comprehensive understanding of the return quality of fine wine investing. In addition, while previous research papers have investigated the diversification potential of fine wine on relatively short-term basis, this study examines the diversification potential on long-term since the dataset consist of observations from 1988 to 2018. Lastly, to the author's knowledge the inflation hedging properties of fine wine investing has not been investigated previously and, therefore, this study provides novel information on whether fine wine investments can be regarded as a hedge against inflation.

The focus of the analysis is in the financial performance of fine wine rather than the taste characteristics and utility of consumption, which is why this presented results do not bring value to wine consumers. Instead, the results will provide useful information for both individual and institutional investors by explaining what kind of role fine wine can have in an investment portfolio in terms of risk-adjusted performance and diversification.

1.4 Structure of the thesis

The second chapter consist of literature review, where the relevant previous research papers are discussed. In the beginning of the third chapter, fine wine investment is described and topics, such as how to invest in fine wine, what is investment-grade wine and price behaviour of fine wine are presented. Further, theory regarding portfolio formation, asset pricing and performance measurement completes the third chapter. The fourth chapter includes information of the data collection, while the fifth chapter contains the used methodology of this study. Results are presented in the sixth chapter and the summary in the seventh chapter concludes the thesis.

2 LITERATURE REVIEW

This chapter presents the pertinent literature regarding wine as an investment asset. The results for previous research papers regarding fine wine investments have been somewhat dependent on the time period of the study. For example, Dimson, Rousseau & Spaenjers (2015) find positive correlation between the returns of fine wine and equities while Masset & Henderson (2010b) claim that fine wines are uncorrelated or only slightly correlated with traditional assets and therefore can provide a hedge for the investor's portfolio. Additionally, Krasker (1979) presents evidence from 1973 – 1977 according to which fine wine investments would not be profitable investments, when Jaeger (1981) finds the opposite by extending the dataset by 4 years to cover the period from 1969 to 1977. The contradicting findings by Krasker (1979) and Jaeger (1981) show that the research results regarding fine wine investments can be highly dependent of the time period of the study.

Aytaç et. al. (2016) examine the role of fine wine as an investment in French portfolios by collecting data from London International Vintners Exchange (Liv-ex) and WineDex indices. The authors' aim is to study if fine wine can provide diversification benefits to investment portfolios between the years of 2007 and 2014. The performance of fine wine is measured by adding 5% to 100% of fine wine in the portfolio and examining the impact on performance using Sharpe ratio and modified Sharpe ratio, where modified value-at-risk is used instead of standard deviation. The results suggest that in most cases the performance of the portfolio increases when the proportion of fine wine in the portfolio increases. Moreover, investors with higher risk-aversion tend to achieve a greater increase in portfolio performance. The optimal weight of fine wine in the portfolios vary between 14% and 99%. Finally, wines from the Bordeaux region are most profitable and Aytaç et al. (2016) argue that Bordeaux wines outperform other regions because of Bordeaux wines' worldwide reputation. Bouri, Gupta, Wong & Zhu (2018) find similar results by studying the role of fine wine within a portfolio of equities, bonds, gold and housing by using stochastic-dominance and mean-variance approaches. The results indicate that among the considered assets, fine wine investments are the most profitable. In addition, portfolios with fine wine are more profitable compared to portfolios without fine wine. Furthermore, Bouri et. al. (2018) point out that fine wine investment market seems inefficient since it is possible to earn abnormal returns via arbitrage by buying the wine at a cheaper price from, for example, one auction and at the same time selling the same wine for a higher price in another auction. However, as the expenses of investing is not included in the study, adding the costs related to fine wine investing could offset the arbitrage opportunities.

Masset et. al. (2010a) analyse risk, return and diversification benefits of fine wine over the period 1996 – 2009. The emphasis of the paper is on periods of economic downturns so the impact of financial crisis on the performance and trading activity of wines can be evaluated. Masset et al. (2010a) claim that especially during market crises, fine wines tend to yield higher returns with lower volatility when compared to stocks. For a private investor, fine wine investments can be beneficial both as a separate asset class or as an addition to the portfolio. The authors point out that adding fine wine investments in a portfolio increases returns while simultaneously reducing risk in the portfolio. Results obtained from the Capital Asset Pricing Model (CAPM) show that the alphas of fine wine investments are significantly positive while the beta coefficients are low. To conclude the findings of the paper, fine wine returns are mostly related to economic conditions instead of the market risk. However, Burton & Jacobsen (2001) find the opposite, by investigating the rate of return on Bordeaux wine over 1986 – 1996. Repeat-sales regression is used to analyse wine prices. The authors suggest that wine cannot be regarded as an alternative to equity investments in terms of average annual return. Additionally, the volatility of wine makes it even less desirable as an investment.

Sanning et. al. (2008) use the CAPM and the Fama-French Three-Factor Model to compare, whether Bordeaux wine returns on vintages ranging from 1893 to 1998 over the period 1996 – 2003 have been more favourable compared to other assets, when measured with mean and variance. By using monthly repeat transactions for individual wine-asset sales, the authors find that the excess returns for wine are large and positive with low exposure to Fama-French Three-Factor Model risk factors. Hence, the results suggest that wine investments can be viable investment assets, either as a part of a diversified portfolio or alone.

Dimson et al. (2015) study the returns of investments in fine wine over a time period of 1900 – 2012. Data for the research paper is collected from two different sources: auction prices are collected from Christie's auction house and retail list prices are collected from Berry Bros. & Rudd. By using a value weighted arithmetic repeat-sales regression, the authors estimate a 4.1% real return, which exceeded bonds, art and stamps. Equities, on the other hand, have outperformed wines during the research period. Furthermore, Dimson et. al (2015) investigate the impact of aging on wine prices for which they build a model that ties the values of consumption and ownership dividends to financial wealth. The value of low-quality wines increases little after the wine is bottled but when the trading volume decreases, the prices increase in almost linear fashion. High-quality wines, by contrast, increase strongly in value during the time the wine matures, but the price stabilizes after a few decades. The increase in value starts again when the wines become antiques, i.e. when the wine has value only as a collectible and not as a consumable anymore. The finding of increasing value beyond maturity suggest that there can be a nonfinancial payoff in the ownership of a rare bottle, thus, wine investments show similar characteristics as other collectibles, such as art or stamps.

Lucey & Devine (2015) study Bordeaux and Rhône wines as an investment before the financial crisis, during a period from January 1996 to January 2007. The results indicate that at a cumulative index level, fine wine can outperform "risk-free" assets, for example T-bills, in terms of return but also with significantly lower risk than the stock market. Overall, fine wine is regarded as an attractive investment instrument by Lucey et al. (2015). However, fine wine investments of low volume or, done by inexperienced investors might not be beneficial, since returns between individual wines may vary significantly. Therefore, investing via wine funds or traded indices could be more appropriate for an individual investor.

Bodie (1983) claims, that the purpose of commodity futures markets is to hedge against risks and unexpected changes in the prices for industrial and agricultural commodities and, therefore can also hedge against inflation. In his paper, Bodie (1983) examine a diverse basket of commodity futures in an inflationary environment. The risk-return trade-off of futures contracts are studied as supplement to bonds, bills and stocks. By utilizing the mean-variance framework introduced by Markowitz (1952), the results suggest that commodity futures hedge against unexpected inflation, while bonds, bills and stocks seem to be negatively affected. However, Erb et. al. (2006) state, that even though commodity futures can offer a hedge against inflation, there is no empirical evidence that all commodity futures or average investment in commodity futures would be good inflation hedges. The inflation hedging properties, according to Erb et. al. (2006), are driven by the composition of the portfolio and that the portfolio, that maximize the inflation hedging ability includes mostly futures for commodities, which are difficult to store, such as heating oil, copper, live cattle and live hogs.

Alternative investments in general, differ from traditional assets. For example, over a time period from January 1980 to February 2006, Campbell (2008) study art as an investment and find that the low correlation with other asset classes offer benefits in terms of diversification when including art in an investment portfolio. Different to many of the studies regarding alternative investments, Campbell (2008) considers the transaction costs, which are substantial in the art market. Also, Dimson & Spanjers (2014) highlight the significance of costs, when investing in collectibles. The authors show that investments in collectibles, which include art, violins and stamps, are more profitable than T-bills, government bonds and gold between 1900 and 2012. However, even though the long-run returns are higher, the high costs, the vulnerability for frauds and exposure for fluctuating tastes makes emotional assets too risky for investors, who do not derive pleasure from owning collectibles.

Worthington & Higgs (2003) examine art alone as an investment. The authors test the short and long-term relationships between different art markets and equity markets by using Granger non-causality tests, multivariate cointegration procedures, generalised variance decomposition analyses and level VAR. Over a period of 1976–2001, the results indicate a significant causal linkage between various painting markets and between equity markets and art markets. However, most painting markets are relatively isolated from equity markets, as equity markets explain less of the variance in art markets compared to other art markets, which shows evidence that there are opportunities for portfolio diversification in art. Nevertheless, the return for art works are significantly lower and the risks are considerably higher compared to traditional financial markets.

There are millions of different stamps in the world and the prices vary from a few pennies to a few million pounds. As there are approximately 30 million stamp collectors in a relatively active stamp market, Veld & Veld-Merkoulova (2007) examine the diversification benefits of investing in stamps over a period from November 2002 to November 2006. The authors observe the profitability of adding Stanley Gibbons 100 index, which is an index for stamps, to a portfolio of stocks and find, that the rate of return compared to British stock indices is lower. However, the results from capital asset pricing model indicate that stamps can offer diversification benefits both for British and American investors. However, the transaction costs, which are stated to be approximately 20%, are not accounted for in the study. Therefore, Veld & Veld-Merkoulova (2007) suggest that stamp investments make sense only, in case the stamps are held for a long period of time.

3 THEORETICAL FRAMEWORK

This chapter gives an overview on fine wine as an investment asset and what kind of wine can be regarded as investment-graded wine. Further, the different methods of how to invest in fine wine and the factors affecting the prices of fine wines are presented. In addition, as fine wine investing differs with traditional investment assets in several ways, the cost structure and risks related to fine wine investing are also discussed. Lastly, the chapter is concluded with theory regarding portfolio formation, asset pricing and performance measures.

3.1 Wine as an investment

Pickup (2015) states that, investing in fine wine requires more capital compared to, for example, stock investments. In general, the invested capital should not be needed in the near future and the preferable investment horizon should be at least 5 – 10 years. Instead of buying larger quantity of cheaper wines, the preferable method is to buy the best possible wines. This way the possible storage costs remain lower, since the storage costs increase when the number of wine lots to be stored increases.

Wine needs to be stored properly, and for an individual investor, one option is a bonded warehouse. The prices of wines, which are stored in a bonded warehouse, can be worth 50 – 100% more compared to wines, which are stored elsewhere. The reason for higher value is that storing the wine in a bonded warehouse provides optimal storage facilities and a method for tracing provenance since every stored case has an audit trail. The wine cases might change owner several times without ever leaving the warehouse itself. (Wine Investment 2018a.)

According to Dimson et. al. (2014), investors, who invest in collectibles are usually high-net-worth individuals. Furthermore, Dimson et. al. (2014), who cite Barclays (2012) state that the average high-net-worth individual holds nearly 10% of his/her wealth in collectibles with limited supply. However, changes in wealth patterns is a risk for all collectibles, as it can impact the demand of the collectibles and therefore, cause a decrease in prices. Nevertheless, investing in collectibles might be of interest to investors, with already diversified portfolio with financial assets and a long investment horizon. Lastly, investments in collectibles can be rational for investors, who derives utility from owning them.

3.1.1 French wines and investment-graded wine

France has a long tradition of producing top class wines ever since 1600s. The climate in France is varying, which makes it possible to grow almost any kind of grapes. A coastline of 5500 kilometers, mountains in the east and south, and large rivers, such as Seine, Loire, Garonne and Rhône create optimal conditions for wine production. In France, wines are classified based on their quality, and the best wines can receive grand cru or premier cru classification. However, the requirements for grand cru and premier cru classifications are extremely high, which makes it unrealistic for most producers to receive either of the classifications. (Karlsson 2014: 17–21, 66.)

There are 11 major wine regions in France. In the North East, there are Champagne, Alsace, Burgundy and Jura, while Rhône, Savoy and Provence are located in South East. Languedoc-Roussilon and South West are, as the name for the second region indicates, in South West and Loire is in the West. In addition to Loire, Cognag is in the West as well, and it is regarded as a wine region, even though the wine is distilled to cognac. The most famous wine region, Bordeaux, locates in South West in the coast of the Atlantic Ocean. Nearly 120000 hectares of vineyards makes Bordeaux one of the largest wine regions in France. From the whole region, 89% is farmed with blue grapes, while 11% is farmed with green grapes. The vineyards in Bordeaux region can be called Chateaus, and there are approximately 7650 Chateaus in Bordeaux, with an average size of 15 hectares. (Karlsson 2014: 27–29, 108–110, 114, 325.)

Many of the most famous wines in the world over the past 150 years have been produced in Bordeaux. The most famous brands originate mostly from vineyards in Pauillac, St-

Émilion and Pomerol. One of the best and most expensive wines is Pomerol's Château Petrus. (Clarke 1999: 90–91; Karlsson 2014: 124.) Pomerol's Château Lafleur, on the other hand, can be either extremely profitable or a nightmare to an investor, since it is the most faked wine due to its high quality and rareness. Since 1855, Château Lafite from the Bordeaux region has been unanimously voted as the best wine in the world. Furthermore, Bordeaux region produces several quality wines such as Château Petrus, Château Latour and Château Cheval Blanc. Other famous vineyards in Bordeaux with investment potential are Margaux, Sauternes and Graves. (Nuikki 2015: 90–94, 112–115, 132–136.)

Several countries produce investment-grade wine. In Europe, France, Spain, Portugal, Germany, Hungary and Austria all produce top wines; however, the best and most famous wines are produced in France, especially in the Bordeaux and Burgundy regions. (Nuikki 2015: 19, 28–43.) In Burgundy region, which is located in the North East in France, the climate is cooler than in Bordeaux. Contrary to Bordeaux region, Burgundy wines are mostly white wines, since only 39% of the total wine production is red wine, while 61% is white wine. In total, the size of Burgundy region is approximately 28000 hectares. (Karlsson 2014: 132–135.) Since Burgundy is smaller than Bordeaux the produced amount is smaller Thus, the wines from Burgundy region are less traded. Wines from roughly 15 different producers from Burgundy region are traded on a daily basis. (Nuikki 2015: 30.)

The heart of Burgundy is Côte d'Or, where the most valuable wines in France are produced. The best-known village in Côte d'Or is Vosne-Romanée, which is labelled as the world's leading village farming Pinot Noir grape. There are six grand cru vineyards in the village: La Romanée, Romanée-Conti, Richebourg, La Tâche, La Grande Rue and Romanée-Saint-Vivant. (Karlsson 2014: 141.) Romanée-Conti has been successful in wine markets since the top 26 vintages from Romanée-Conti vineyard earned on average 22% a year through 2011 – 2015. (Nuikki 2015: 86.)

From all wines in the world, only a fraction can be considered as investment-graded wines. Typically, good investments are wines, that are top quality, with limited production, that are from a specific area and which can be expected to have a long life.

Nearly all investment-graded wines are red wines, but also the best sweet white wines and top champagnes have the quality to be invested in. The best red wines reach their peak after 20 – 30 years, however, they can maintain the quality in flavour for over 70 years. Wine critics grade wines based on the quality of the wine. Maximum score is 100 and usually wines, which score over 90 points can be regarded as investment-grade wines and wines, which score over 95 points are considered top investments. However, only 0.2% of all the wines in the world are graded with a score over 95 points. (Nuikki 2015: 19 – 22.)

3.1.2 How to invest in wine

According to Aytaç et. al. (2016) There are five different ways to invest in fine wine: the first is to buy wine bottles or en-primeur wines, which are wines that are still in barrels, straight from the vineyard to own wine cellar. The second method is to buy wine bottles from auctions which are held in cities around the world. The third way is to invest in a wine investment company with a "turnkey" cellar, which can be managed by a professional or the investor him/herself. The fourth option is to invest in a wine fund and the fifth possibility for an investor is to buy a vineyard parcel, which is managed by a professional wine grower.

Internet has eased the trade of wines, with different merchants offering large selections and easy price comparison of wines. After purchasing the wine through a merchant, the buyer can choose how to pay and how, when and where to the wine is delivered. (Nuikki 2015: 186 – 188.) Wine bottles can also be purchased from auctions by attending the auction personally, by bidding online or over the phone and by making a bid in advance. For example, in Sotheby's (2018a) auction, which is one of the famous auction houses, all bids from every source are acknowledged and the highest bidder purchases the wine. Auctions are open to the public and there is no obligation to bid for wines. The bidding begins at a price that is lower than its reserve, which means the minimum price at which the seller is willing to sell the wine in question (Sotheby's 2018b). In case the final offer is below reserve price, the wine will not be sold.

It is difficult to establish a fair value to wine since wine prices reflect supply and demand at a specific moment, which is why investing in wine require deep knowledge of the market. Further, there is no centralized market place, there is risk for counterfeits, wine is fragile and the costs of trading and storing wine are high. Due to these problems, investing in wine fund, where a professional manages the fund, has become more popular. Mostly wine funds invest in Bordeaux region, and more specifically, in the five first growths from Médoc, Pétrus and other Pomerols and St-Emilions. However, some funds also invest partly in Burgundy, Rhône or Italy. Furthermore, the funds usually focus on the best and recent vintages. The biggest problems with wine funds are related to liquidity and pricing. Since it can be difficult to liquidate positions quickly, wine funds have been forced to either file for bankruptcy or suspend their redemptions. Moreover, it is unclear how funds calculate the net asset value (NAV) since many wines are infrequently traded, there is no unique market place and the valuation of wines lack international standards. The fee structure for wine funds is similar to hedge funds. For example, in their study, Masset et. al. (2015) use nine large funds, from which most charge a 1.5% – 2.0% management fee plus a 15% – 20% fee based on the performance of the fund. (Masset et. al. 2015.)

An additional option for an investor is to invest in a wine related listed company through stock market. However, mostly listed wine related companies are not qualified as fine wine investments since the amount of listed companies relating to fine wine is limited, except in Champagne, where there are four listed companies: Lanson-BCC, Vranken-Pommery Monopole, Laurent-Perrier Group and LVMH. Moreover, the revenues for these companies mostly do not derive from wine. Lastly, the profits to investors do not necessarily originate from the appreciation of wine price, but from the margin made from the sales, which is why wine related stocks are excluded from this thesis. (Pichery & Giraud-Héraud 2013.)

3.1.3 Factors affecting pricing and returns of fine wine

The demand of fine wines has been growing rapidly. The number of consumers has increased as the emerging economies, such as Russia and China, have become wealthier.

As the wine is consumed, the supply decreases. At the same time, the number of consumers grow and as time goes by, the quality of fine wine increases, which causes the prices of fine wines to rise. (della Casa & Smith, 2009.)

There are several things that affect fine wine prices and one of the main factors are the scores that fine wines score from wine critics. Ali, Lecocq & Visser (2008) find that the grading of Robert Parker, who is one of the most famous wine critics in the world, especially affect the prices of highly graded en primeur wines. On average, the impact of grading by Parker is claimed to be 2.80 EUR per bottle. For lowly graded wines, however, the impact vanishes. Wine critics grade wines based on the quality of the wine and the grades given by wine critics affect the prices and the demand of the wines.

In addition to the score from the critics, the condition, the quality and the rarity of the wine affect the investment performance of the wine (Nuikki 2015: 18, 22). According to Karmavuo & Lihtonen (2009), also the vintage affects the prices of wines. A good vintage requires optimal climate and weather conditions and long enough growing period. Compared to a worse vintage, a wine of good vintage retains the quality and it can be stored for a longer period. Ashenfelter (2008) states that the quality of the grapes produced depends on the weather during the growing season. For example, the weather in Bordeaux varies from year to year, and the best vintages correspond to years, where the previous winter has been wet, the growing season warm and August and September dry. Furthermore, Ali & Nauges (2007) find that the pricing behaviour largely depend on the reputation of the wine and especially on the ranking in the old classification system.

3.1.4 Costs of storing and trading wine

There are several different costs that investors need to account for when investing in fine wine. The costs associated are larger compared to traditional investment assets, such as stocks and bonds. While the different fees may vary between merchants, this thesis presents more specifically charges and fees from Liv-Ex, which is the leading market place for fine wine in the world. Furthermore, the charges and fees vary also between individual investors, which is why the presented amounts and percentages are not included in the empirical analysis, but the importance of the charges need to be emphasized.

The monthly subscription for Liv-ex, which allows the users access to Liv-ex products and services, cost from 200 GBP a month upward, depending on the purchased package and new members are subject to a sign-up fee of 1,800 GBP. On purchases and sales, the standard commission fee is 2%. Furthermore, Liv-ex charges settlement fees, which cover administration and logistics. For example, for Bordeaux wine, the settlement fees are 3.50 GBP per unit, which equals 42 GBP per a case of 12 bottles. (Liv-ex 2019a.)

Karmavuo & Lihtonen (2009) state, that the wine “lives” in the bottle and in case it is not correctly stored, it matures too fast and gets spoiled. The purpose of storing wine is to age the wine to a point, where it is most enjoyable to drink. Hence, it is essential that the wines are stored properly in order to maintain the quality and the therefore the price of the wine. Optimal wine storage is a place, where the temperature is stable, the air is humid, and the room is dark and does not vibrate. The ideal temperature is between 14 – 16 °C and the humidity should be 60 – 70%, so the flavour develops, and the labels remain in top condition. The cork has an important role in storing wine since oxidation is a central part of the wine’s ageing process. Natural cork “breathes”, which allows the wine to age slowly. Wine bottles with natural cork should be stored horizontally so, that the cork will not dry and allow too much oxygen into the bottle to spoil the wine. Other used cork types are screw cap and crown cap, however, these are mostly used for wines, which are not stored for a long time or for which oxidation is not preferred. (Karmavuo & Lihtonen 2009: 102, 106.)

Storage costs for a case of wine in bond vary between 10 and 25 GBP a year (Wine Investment 2018a). Alternatively, in their paper, Dimson et al. (2015) estimate 0.13%, 0.24% and 0.23% storage costs per a dozen bottles in 1980, 1990 and 2000 respectively. The storage cost estimates are calculated from Berry Bros. & Rudd (BBR) average list prices. In addition to storage costs, wine needs to be insured against accidental breakage, theft, fire and other hazards. According to Meltzer (2005), the premium investor pays, and the exact coverage depends on the insurer. The typical insurance cost is approximately 0.5 %. Lastly, Fogarty (2007) states that when wine is bought at auction, the buyer's premium is usually between 10% and 15%. Also, the seller typically faces a fee of at least 10% of the value of the wine that is being sold.

Compared to assets, for which capital gains taxes are applied, the taxation for wine is lighter. It is important to note that the taxation is country-specific, which is why for an investor, it might be necessary to consult local tax advisor. Since the empirical part in this thesis is conducted with Liv-ex index, a London based marketplace, taxation in United Kingdom is briefly presented. In United Kingdom, capital gains tax does not apply for wine, since wine is mostly considered as "wasting asset", which means those whose predictable life is less than 50 years (The National Archives, 1992). On the other hand, wine is liable for duty and value-added tax. However, in case wine is stored in bond, the customs duty or the value added tax do not need to be paid before the wine is delivered out of the bonded warehouse. (Wine Investment 2018b). Even though the storage costs and transaction costs for investing in fine wine are high, Fogarty (2007) claims that the costs are almost offset by the beneficial tax treatment.

3.1.5 Wine investments and liquidity

Liquidity means the ease and speed, with which an asset can be sold in the market. Liquidity can be split to parts in a sense, that part of liquidity can be seen as the cost of engaging in a transaction, while one part is the ability to sell the asset fast. The final part is the price impact, which means the movement in asset price when making a larger trade. On the other hand, illiquidity can partly be regarded as the discount from fair market value, which investor need to accept when selling the asset quickly. In case the asset is perfectly liquid, no illiquidity discount would be involved in the transaction. The higher the transaction costs are, the higher is the illiquidity discount. Since the expected return of an asset is higher, in case it can be bought with a lower price, therefore, less liquid assets should offer higher average rates of return. However, the illiquidity premium does not need to increase in same proportion as transaction costs. Hence, the holding period for illiquid assets should be longer so the impact of high trading costs is shunned. (Bodie 2014, 310–312.)

Traditionally purchasing fine wine has been linked to emotional factors instead of purely investing purposes. Fine wine is a tangible asset, which can be consumed, and cannot be traded as fast as other assets, which means that the liquidity for trading fine wine is low. Furthermore, fine wine does not provide dividends or coupons like stocks and bonds. (Aytaç et. al. 2016.) Since wine does not pay dividend or coupon, Lucey et. al. (2015) claim, that the value of fine wine is derived either from the difference between purchase price and the sales price minus the costs associated with trading or the utility of consuming the wine. Also, according to Masset & Weisskopf (2015), arbitrage opportunities may appear in the segmented fine wine market, however, it is difficult to exploit them because of low liquidity and high transaction costs.

3.1.6 Risks of wine investing

Since wine is an agricultural product, it is subject to several systematic and unsystematic risks. Such risks as human risks of the farm operator, production uncertainty, price uncertainty, technological uncertainty, policy uncertainty, asset risk and financial risk are all factors that can affect farmers and therefore the price and return of wine. Production uncertainty is related to the quality of output, which is a result of uncontrollable elements, for example, weather. The fluctuation in demand creates uncertainty to pricing while the evolution of production techniques might make past investments obsolete. Further, political uncertainty has an impact on, for example, regulation, interest rates and exchange rates and financial risk and can therefore create uncertainty for investments and financial result. Lastly, while insurance normally covers or at least contributes to reduce asset losses, theft, fire and damage to equipment of buildings are common risks agricultural farmers face. (see European Commission 2001; Moschini & Hennessy 1999.)

When buying wine online, paying online with credit card or wire transfer is simple. However, even though the paying is easy, usually the largest risk is also related to the payment method since the wines are paid in advance. Although the internet has facilitated the trade, it has also increased the risk of fraud, since for a buyer it is difficult to verify the quality and origin of the wine through the internet. Nuikki (2015: 236) claims that in

2015, every tenth and in 2020, every third sold wine is estimated to be fake. Due to the high level of risk, an investor should only trade through well-known merchants and auctions to minimize risk. (Nuikki 2015: 186.) Furthermore, due to the risk profile of wine market, Kourtis, Markellos & Psychoyios (2012) suggest that futures and option contracts could be developed for standardized wine price indices to meet the market participants' needs for risk management and to improve market completeness.

3.2 Portfolio management

3.2.1 Modern portfolio theory

Markowitz (1952) introduced how mean-variance analysis can be implemented to portfolio selection. In this approach, investors are assumed to be rational, risk-aversive and investors wealth is diversified across a variety of assets. Diversification can decrease variance without decreasing the expected return. However, diversification does not completely eliminate the variance, unless the correlation coefficient between assets is -1. The investor can select a portfolio, which has the highest possible expected return for a given level of variance in returns or lowest variance of returns for a given level of expected return, and these portfolios are called *efficient portfolios*. When all the efficient portfolios are plotted in a graph, the result is a hyperbolic line. The hyperbolic line is called the *efficient frontier*, which is presented in Figure 1. Depending on the investor's risk aversion, rational investor will try to move as far up and to the left on the graph as possible. The *minimum variance portfolio* is the portfolio located most to the left in the set of efficient portfolios, and this portfolio has the lowest variance of all efficient portfolios.

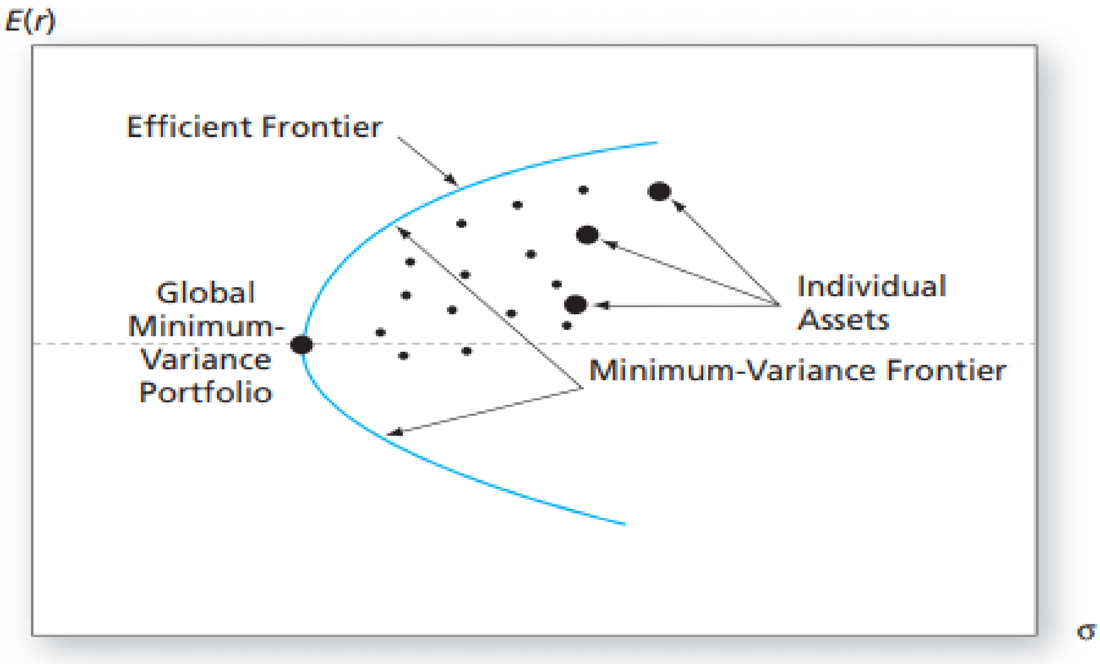

Figure 1. The minimum-variance frontier of risky assets.

Source: Bodie, Kane & Marcus (2014)

Investors are risk aversive in such manner, that if risk premium of an investment is zero, the investor would not invest money in it. Positive risk premium needs to exist, otherwise risk-averse investors would only invest in risk-free assets. Intuitively, investors seek investment opportunities with high expected return and low risk and therefore portfolios with most attractive risk – return profile provide the highest utility to investor. The utility of a portfolio can be measured with the following formula:

(1) $$U = E(r) - ½A\sigma^2$$

where U represents the utility score and $E(r)$ is the expected return of a portfolio. ½ is a scaling convention, while A denotes an index of investor's risk aversion and σ^2 is the variance of the portfolio. (Bodie et. al. 2014: 129, 170.)

3.2.2 Asset pricing models

A centrepiece for modern financial economics is the Capital Asset Pricing Model, mostly referred to as CAPM. Stemming from Harry Markowitz's modern portfolio theory, the CAPM was published in mid-1960s by William Sharpe, John Lintner and Jan Mossin. The model predicts the relationship that should be observed between risk and expected return of an asset. The formula for the CAPM is stated as follows:

$$(2) \qquad E(r_i) = r_f + \beta_i[E(r_M) - r_f]$$

with

$$(3) \qquad \beta_i = \frac{Cov(r_i, r_M)}{\sigma_M^2}$$

where $E(r_i)$ is the expected return of asset i. r_f is the risk-free rate and $E(r_M)$ denotes the expected return of the market. β_i is the beta of asset i and it measures the covariance of asset i with the market portfolio as a fraction of the total variance of the market portfolio. The CAPM relies on a set of assumptions and the model can hold only in case the assumptions are true. However, the model is relying on invalid assumptions and therefore cannot provide perfectly consistent results and fully withstand empirical tests. The CAPM assumes that investors are rational, mean-variance optimizers, limited to a common single-period horizon and have homogeneous expectations, i.e. they have identical input lists. Further, the model assumes that all assets are tradeable on public exchanges, investors can borrow and lend at risk-free rate, short positions are allowed, all information is available for all investors and there are no taxes or transaction costs. Even though the model fails many empirical tests, the logic behind the model keeps it at the center of the finance industry. (Bodie et. al 2014: 291, 297, 302 – 305.)

Multifactor models can describe security returns better than the traditional CAPM. Fama & French (1993) introduced a multifactor model with 3 risk factors: market risk premium, size and value. Carhart (1997) added momentum factor to the equation, where a long position is taken for stocks that have performed well over last 12 months and short position is taken for poorly performing stocks. Fama & French (2015) extended their model from 1993 by adding profitability and investment factors to the formula. The equation is following:

(4) $$E(r_i) - r_f = \alpha_i + \beta_1\big(E(r_M) - r_f\big) + \beta_2 SMB + \beta_3 HML + \beta_4 RMW + \beta_5 CMA + \varepsilon_i$$

where $E(r_i)$ is the expected return of asset i and r_f is the risk-free rate. r_M denotes the value-weighted portfolio return. SMB is the size factor, which shows the return of small stock portfolio minus big stock portfolio. HML is the difference between the portfolio returns of high book-to-market ratio stocks and low book-to-market ratio stocks, and it is called the value factor. The last two factors are RMW and CMA, which are the profitability factor and investment factor respectively. RMW is the difference between robust and weak firm portfolio returns, while CMA denotes the difference between conservatively and aggressively investing companies. β_1, β_2, β_3, β_4 and β_5 are factor loadings, which indicate the sensitivity of the asset returns to corresponding risk factor. Lastly, ε_i is the error term.

3.2.3 Risk-adjusted portfolio performance measures

Investors are interested in the expected excess return they can earn by investing in a risky portfolio, i.e. a portfolio with uncertain rate of return instead of investing in a risk-free asset, such as T-bills and what kind of risk would then incur. Standard deviation is widely used as a measure of risk and the risk is best to measure by standard deviation of excess returns and not total returns, since risky assets are priced in a way that the risk premium is commensurate with the risk of the excess returns. The attraction of a portfolio is often measured with Sharpe ratio, which is the ratio of risk premium and the standard deviation of excess returns. The formula for Sharpe ratio is described as follows:

(5) $$\frac{\bar{r}_P - \bar{r}_f}{\sigma_P}$$

where $\bar{r}_P$ is the average return of the portfolio and $\bar{r}_f$ is the average risk-free rate. σ_P is the volatility of excess returns of the portfolio. (Bodie et. al. 2014: 134.)

Treynor ratio is similar measure as Sharpe ratio, with the difference that Treynor ratio informs excess returns per unit of risk by using systematic risk instead of total risk. Therefore, the formula for Treynor ratio is:

(6) $$\frac{\bar{r}_P - \bar{r}_f}{\beta_P}$$

where β_P is the beta of the portfolio. (Bodie et. al. 2014: 840.)

Another performance measure, which uses mean-variance criteria is Jensen's alpha. Jensen's alpha denotes the average portfolio return, which exceeds the prediction by the CAPM. The formula is stated as follows:

(7) $$\alpha_P = \bar{r}_P - [\bar{r}_f + \beta_P(\bar{r}_M - \bar{r}_f)]$$

where $\bar{r}_P$ is the average portfolio return and $\bar{r}_f$ is the average risk-free rate. β_P denotes the beta of portfolio, while $\bar{r}_M$ is the average market return. (Bodie et. al. 2014: 840.)

3.2.4 Portfolio risk measures

The excess returns are usually assumed to be normally distributed to simplify portfolio selection. However, in reality, the excess returns are rarely normally distributed. By calculating the higher moments of the return distribution, the deviations from normality of returns can be discovered. *Skewness* measures the asymmetry of the distribution and it is the ratio of the average cubed deviations from the average, which is called the third moment. When extreme positive deviations are cubed, the result is a positive skew with distribution skewed to the right as in Figure 2. Negatively skewed distribution is skewed to the left. (Bodie et. al. 2014: 137 – 138.) Skewness is calculated as follows:

$$Skew = Average\left[\frac{(r-\bar{r})^3}{\hat{\sigma}^3}\right] \tag{8}$$

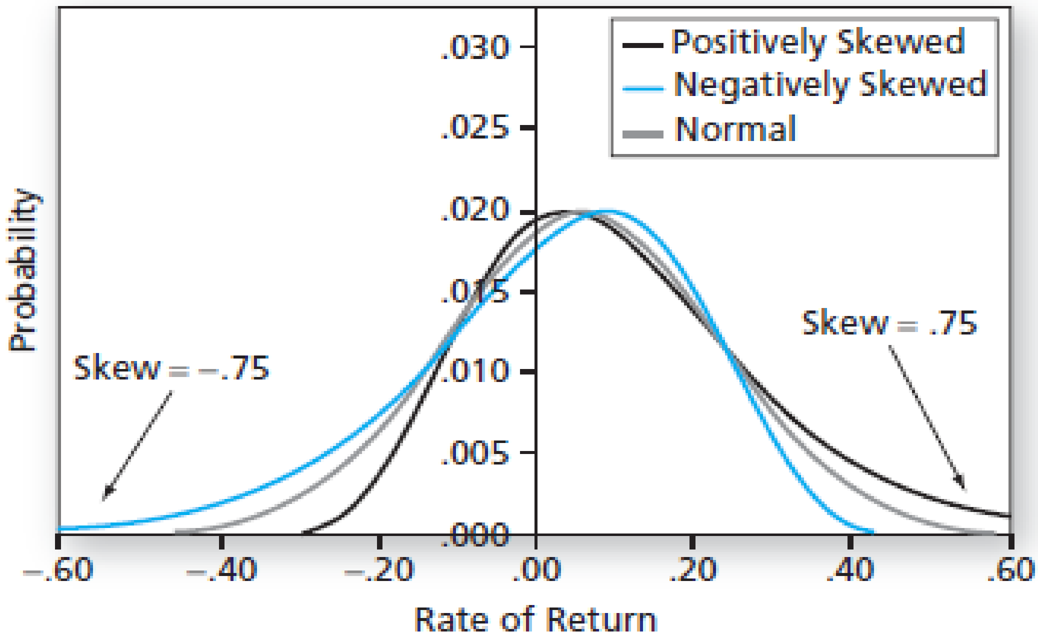

Figure 2. Normal and skewed distributions.

Source: Bodie, Kane & Marcus (2014)

The second indicator, which reports deviations from normality is *kurtosis*. Kurtosis reports the possibility of extreme values on either side of the mean. The tails are then "fat", as shown in Figure 3, which means that there the probability for extreme values is higher compared to normal distribution and the probability for values near the center of the distribution is smaller. (Bodie et. al. 2014: 138 – 139.) The formula for kurtosis is following:

(9) $$Kurtosis = Average\left[\frac{(r-\bar{r})^4}{\hat{\sigma}^4}\right] - 3$$

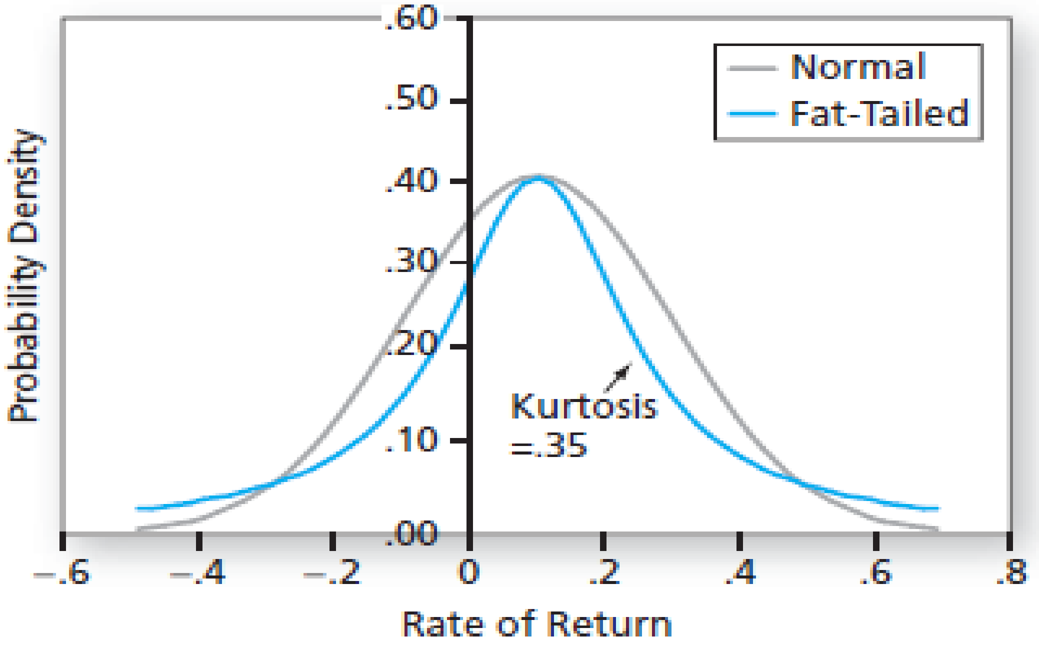

Figure 3. Fat-Tailed and normal distribution.

Source: Bodie, Kane & Marcus (2014)

In case the distribution of returns is not normal, standard deviation is no longer optimal measure for risk. Therefore, measures, which report the vulnerability for extreme negative values need to be considered. The value at risk (VaR), expected shortfall and Sortino ratio are such measures and hence, need to be discussed. VaR reports the best rate of return for a given quantile of worst-case future scenarios. The quantile, for example 5% of a distribution, is the threshold below which the worst performing 5% exists. VaR for the normal distribution is determined by the standard deviation and mean of the distribution. In case 5% of the number of observations is not an integer, interpolation needs to be used to obtain VaR. The 5th percentile of the distribution equals -1.65, thus the VaR is stated as:

(10) $$VaR(.05, normal) = Mean - 1.65\sigma^2$$

The VaR is an optimistic measure in a way that it reports the highest return and, therefore, the smallest loss of the 5% worst-case scenarios. Conditional tail expectation (CTE) or the more commonly used expected shortfall (ES) focuses on expected loss that is suffered when being in one of the worst-case scenarios. (Bodie et. al. 2014: 140.) Assuming normally distributed returns, the formula for calculating ES according to Bodie et. al. 2014, who cite Treussard (2007) is:

(11) $$ES = \frac{1}{.05} * \exp(\mu)\, N[-\sigma - F(.95)] - 1$$

where μ is the mean of continuously compounded returns and σ is the standard deviation. N is the cumulative standard normal distribution, while F is the inverse of N.

Lower partial standard deviation (LPSD) is a measure, which considers only negative outcomes of the return distribution and the negative excess returns instead of negative returns only. LPSD squares the negative deviations from risk-free rate and then takes the square root to obtain the negative deviation. However, LPSD does not account for the frequency of negative excess returns. Sortino ratio is a variant of Sharpe ratio, which uses LPSD as the risk measure instead of standard deviation and therefore considers only the “bad” returns. (Bodie et. al. 2014:140.)

4 DATA

This chapter presents the collected data for the empirical research. Since fine wines are infrequently traded, all data for all asset classes are monthly observations. Furthermore, the used indices are either already denoted in USD or converted to USD to avoid biased results. To evaluate fine wine as an investment, Liv-ex Fine Wine Investables -index is used as a proxy, since Liv-ex indices are used in several studies [e.g. Kourtis et. al. (2012); Lucey et. al. (2015); Aytaç et. al. (2016); Bouri et. al. (2018) and Masset & Weisskopf (2018)] and the Liv-ex Fine Wine Investables -index is the oldest from Liv-ex indices. In addition, Liv-ex is widely considered as industry benchmark in fine wine. The data is obtained from Liv-ex, and since Liv-ex Fine Wine Investables -index was launched in January 1988, a time period from January 1988 to December 2018 is chosen for this thesis. The index consists of approximately 200 wines from 24 top Bordeaux chateaux (Liv-ex 2019b). Liv-ex indices are calculated using Liv-Ex Mid price logic (Liv-ex 2019c), which means finding the mid-point between the lowest offer price and current highest bid price on Liv-ex trading platform. The obtained prices are then verified for robustness by Liv-ex own valuation committee. Liv-ex indices are GBP denoted, hence, the index is converted to USD using average monthly exchange rate collected from Federal Reserve Bank of St. Louis website.

For stocks, as in the paper by Masset et. al. (2010a), S&P 500 index is used as a proxy for large stocks and S&P 400 for mid cap stocks. S&P 500 index includes 500 leading U.S. companies, while S&P 400 consist of 400 mid-sized U.S. companies. However, since S&P 600 index was not launched until 1994, Russell 2000 index is chosen as proxy for small cap stocks. Russell 2000 index is formed of 2000 small U.S. companies and it is widely adopted as the small cap benchmark by institutional market participants. The data for Russell 2000 index is collected from Financial Times Stock Exchange (FTSE) Russell website. Also, similarly to the research papers by Aytaç et. al. (2016) and Masset et. al. (2010a), Morgan Stanley Capital International (MSCI) World ex-USA index is used as a proxy for international stocks excluding the U.S. The monthly data for S&P 500, S&P 400 and Russell 2000 is obtained from Yahoo! Finance -website and the closing prices are adjusted for both dividends and splits. MSCI World ex-USA index includes large cap and mid cap companies from 22 developed markets countries (MSCI 2019a) and the data is collected from MSCI website.

Since the U.S. is the largest market and stocks are mostly examined with U.S. stocks in this study, also the investment opportunity for bonds is analysed with a bond index based in the U.S. The chosen proxy for bond investing is the Bank of America Merrill Lynch U.S Corporate Master Index, which includes securities that are rated as investment grade by Moody's, Standard & Poor's and Fitch and an investment grade rated country of risk. (ICE Benchmark Administration Limited (IBA) 2019a). As the risk-free rate, USD denoted 1-month London Interbank Offered Rate (LIBOR) is used since the data consist of monthly observations. The LIBOR is calculated as the average rate at which banks in the London market borrow funds from other banks (ICE Benchmark Administration Limited (IBA) 2019b).

Gold is studied by using Gold Fixing Price of 3:00 P.M. (London time) on the London Bullion Market denoted in U.S. dollars, as in the paper by Bouri et. al. (2018). The London Bullion Market Association replaced the historic London Gold Fix in 2015 (ICE Benchmark Administration Limited (IBA) 2019c). For inflation, Consumer Price Index (CPI) is used as a proxy. The collected data for bond, CPI, fixed income and gold investments are retrieved from Federal Reserve Bank of St. Louis website.

Table 1 presents the descriptive statistics for the sample between January 1988 and December 2018. In total, the dataset consists of 3710 monthly observations. Generally, fine wine and stocks, apart from MSCI world excluding USA -index, have higher monthly returns both on average and by median compared to other asset classes. Conversely, gold and 1-month LIBOR have the lowest mean and median return. As none of the asset classes has a mean return equal to the median return, none of the return distributions are perfectly symmetric. The maximum monthly return ranges from 23.76% per month for fine wine, to 0.80% for 1-month LIBOR. Conversely, minimum ranges from -24.63% for S&P 400 to 0.01% for 1-month LIBOR. The standard deviation is highest for stock indices and gold, while the standard deviation for bonds, 1-month LIBOR and CPI is significantly lower.

Table 1. Descriptive statistics.

	Mean	Median	Maxi-mum	Minimum	Standard deviation	Ske-wness	Kurtosis
Liv-ex	0.72	0.64	23.76	-20.11	3.87	0.58	11.21
S&P 500	0.61	1.04	10.58	-18.56	4.09	-0.78	4.78
S&P 400	0.84	1.24	13.76	-24.63	4.76	-0.88	5.94
Russell 2000	0.67	1.52	15.20	-23.45	5.33	-0.76	4.73
MSCI world ex-USA	0.23	0.56	13.50	-23.41	4.82	-0.66	4.72
Bonds	0.55	0.59	5.41	-7.67	1.45	-0.91	8.07
Gold	0.28	0.17	16.00	-19.10	4.44	-0.07	4.44
1M LIBOR	0.28	0.26	0.80	0.01	0.22	0.33	2.00
CPI	0.21	0.21	1.37	-1.79	0.26	-1.36	14.96
GBP/USD							
No. of ob-servations (N)	3710						

The table provides descriptive statistics of the monthly returns of all variables, except GBP/USD. For GBP/USD, the reported descriptive statistics are monthly exchange rates. The sample consist of monthly observations from January 1988 to December 2018.

Skewness and kurtosis describe the properties of the return distributions of asset classes. For skewness, in general, a value less than -1 or greater than +1 means that the distribution is highly skewed and skewness between -0.5 and 0.5 can be interpreted as approximately symmetric. Perfectly symmetrical distribution has a skewness of 0. Positive skewness indicates a longer tail to the right, while negative skewness means that the left tail of the distribution is longer. Fine wine and 1-month LIBOR have positive skewed distributions, meaning that there are larger positive results than negative results. The return distribution for gold is almost symmetric, but for all other asset classes, the return distributions are negatively skewed.

Kurtosis concerns the likelihood of extreme values in either side of the return distribution. Normal distribution has a kurtosis of 3 and, generally, a distribution with kurtosis over 3 is called leptokurtic and a distribution with kurtosis below 3 is considered platykurtic. Apart from 1-month LIBOR, all other asset classes are leptokurtic, indicating “fat” tails and, thus, more mass in the tails of the distribution compared to a normal distribution.

5 METHODOLOGY

This chapter presents the methodology used in this study. To analyse the return on different asset classes, logarithmic price change is used:

$$(12) \qquad r_{i,t} = 100 * \ln(\frac{P_{i,t}}{P_{i,t-1}})$$

where $r_{i,t}$ is the logarithmic return of asset or index i at time t. $P_{i,t}$ is the asset or index value at time t and $P_{i,t-1}$ is the asset value or index value at time $t-1$. For all asset classes, average annual returns and total returns from the observed time period are calculated both in nominal terms and in real terms. The rate of inflation is calculated as the logarithmic price change in the Consumer Price Index. The average annual returns are calculated using geometric average to capture the compounding effect on returns, which a normal average does account for. For return comparison between asset classes, index values for January 1988 is set to 100 for all asset classes.

The risk-adjusted performance of fine wine investments is compared to stocks, bonds and gold. Previous literature mostly uses Sharpe ratio only as measure of risk-adjusted profitability; however, Sharpe ratio can provide biased results when returns are not normally distributed. Furthermore, Sharpe ratio does not differentiate between upward and downward volatility and, which means it sees also upward movements as risk. Therefore, risk-adjusted performance analysis is extended to contain 4 risk-adjusted performance measures: Sharpe ratio, Sortino ratio, value at risk (VaR) and expected shortfall (ES). For Sharpe ratio and Sortino ratio, the higher the ratios are, the better is the risk adjusted return. Since VaR and ES express losses in the worst-case scenarios in the return distribution, the interpretation is that the smaller the loss, the better is the risk-adjusted performance. Both VaR and ES are tested on 5% level and 1% level.

The second hypothesis of inflation hedging is analysed using models for expected inflation and unexpected inflation. Expected inflation is examined with ordinary least squares (OLS) regression model. The data is time-series, and before running the regression, the data need to be checked for stationarity. OLS regression assumes no autocorrelation, but stationary time-series will cause autocorrelation, which violates the assumption. The stationarity of the variables is checked with Augmented Dickey-Fuller (ADF) unit root test. The regression model is formed following the methodology by Chua & Woodward (1982), who examine the inflation hedging properties of gold:

$$(13) \quad r_{i,t} = \alpha_i + \beta_i CPI_{i,t} + \varepsilon_{i,t}$$

where $r_{i,t}$ is the return on asset class i at time t. β_i is the regression coefficient for inflation rate $CPI_{i,t}$, which is calculated as the natural logarithmic price change in CPI and $\varepsilon_{i,t}$ is the error term. β_i represents the elasticity of asset class i with respect to prices for goods, corresponding the percentage change in asset class i for every 1% change in inflation. In case β_i is positive and statistically significant, the asset provides a hedge against expected inflation. Coefficient value between 0 and 1 means partial hedge and coefficient value equal to or above 1 indicates complete hedge against expected inflation.

However, it is possible that the prices of assets adjust to changes in inflation with a lag, which equation 13 does not account for. Therefore, the following model presented by Fama & Schwert (1977) is deployed, since it captures both the expected and unexpected component of inflation:

$$(14) \quad r_{i,t} = \alpha_i + \beta_1 E(\pi_t) + \beta_2[\pi_t - E(\pi_t)] + \varepsilon_{i,t}$$

where, $E(\pi_t)$ is the expected inflation, which is proxied with previous period's inflation. $[\pi_t - E(\pi_t)]$ is the unexpected component, where the expected inflation is subtracted from inflation at time t. In case an asset is a complete hedge against inflation, both β_1 and β_2 are equal to or larger than 1. In case only β_1 is equal to or larger than 1, the asset is a complete hedge against expected inflation, while a slope coefficient over 1 for β_2 means complete hedge against unexpected inflation. The standard errors are corrected for autocorrelation and heteroskedasticity by using HAC – Newey-West standard errors.

To examine whether wine investments improve portfolio performance, the employed methods are based on the Markowitz portfolio optimization model and are used in studies regarding wine investing (see Aytaç et. al. (2016); Masset et. al. (2010a)). The first step is to create calculate the minimum-variance portfolio with following method:

$$(15) \quad Min[V(r_P)]$$

with

$$(16) \quad V(r_P) = \begin{bmatrix} \sigma_1^2 & \sigma_{1,2} & \cdots & \sigma_{1,n} \\ \sigma_{2,1} & \sigma_{2,2}^2 & & \vdots \\ \vdots & & \ddots & \sigma_{n-1,n} \\ \sigma_{n,1} & \cdots & \sigma_{n,n-1} & \sigma_n^2 \end{bmatrix}$$

$$(17) \quad w_i \geq 0$$

$$(18) \quad \sum_{i=1}^{n} w_i = 1$$

where r_P is the return of the portfolio, w_i and w_j are the weights of capital invested in asset class i and j. $V(r_P)$ denotes the variance of portfolio P returns, where diagonal σ_n^2

values are estimates of variances of individual asset classes, while $\sigma_{n,n-1} = \sigma_{n-1,n}$ denote the covariance between assets. The efficient frontiers are constituted for reference portfolio and portfolio, which is diversified with wine. The reference portfolio consists of S&P 500, S&P400, Russell 2000, MSCI world excluding USA, Bank of America Merrill Lynch U.S Corporate Master, Gold and the 1-month LIBOR. In case diversification is profitable with wine, the efficient frontier with wine is higher compared to portfolio without wine. The second step is to discover the optimal risky portfolio by finding the steepest capital allocation line (CAL), i.e. line with the highest Sharpe ratio. The steepest CAL is tangent to the efficient frontier. For calculating performance measures, minimum variance portfolio and the optimal risky portfolio, Microsoft Excel is used. The regression models for inflation hedging examination are run with EViews.

5.1 Restrictions, assumptions and possible biases

In this study, short selling is not considered to be possible since the objective is to examine positive investment proportions, as the time period of the study is long. Allowing short selling would not add value to this paper since the aim is to investigate the benefits of acquiring fine wine and not selling any asset short. Further, it is necessary to highlight that, especially stocks, which may have high intra-day volatility, the used monthly dataset does not account for daily volatility, but only considers the total price change for each month. Lastly, as the mean-variance framework possesses some important underlying assumptions, it is necessary to present the assumptions, which are considered vital for this thesis.

I. Investors prefer higher returns

This assumption refers to investors always seeking higher returns, and, thus, being dissatisfied. Everything else equal, in modern portfolio theory, investors choose the portfolio, which have higher expected returns over a portfolio with lower expected returns. The underlying assumption of dissatisfaction is in line with the objective of this study to maximize the investor’s returns.

II. Investors are risk-averse and rational

Risk-averse investor avoids risk. Ceteris paribus, investor prefers a portfolio with lower risk (volatility), instead of portfolio with higher risk (volatility). Risk-aversive investors are willing to take more risk only in case the expected returns increase.

III. Utility is purely a function of mean and variance

This assumption highlights, that the utility for investor is derived from returns of the assets. Other factors, such as social, moral and pleasure of consumption is not accounted for, even though consuming fine wine is can be considered as an “spiritual dividend”. This study overcomes the issue by using examining indices instead of physical bottles, since the emphasis is completely on financial gain. Furthermore, modern portfolio theory defines risk as the variance of returns, thus the mean-variance framework considers variance as believable measure of risk.

IV. Normally distributed returns

Modern portfolio theory assumes that returns are normally distributed. However, the assumption for normally distributed returns is usually proven wrong when financial data is observed. Instead, statistical financial data often suggest asymmetry and fat tails. As the descriptive statistics in chapter 4 indicate, the returns for asset classes in this paper are not normally distributed. Since there is no solution to this problem, the results need to be interpreted with caution, however, for comparison of different portfolios, the lack of normality might be of less importance.

V. Zero costs

There are several kinds of costs related to investing, and the costs are always an important factor to consider, when making e.g. an investment plan. However, modern portfolio assumes, that there are no costs related to investing, which means no transaction costs, taxes, storage costs or any other expenses. It is important to emphasize this assumption, as the costs related to investing can be significant, and the size and structure of them can be different for different assets.

6 EMPIRICAL RESULTS

The results from the empirical research are analysed in this chapter. First, return characteristics of fine wine both alone and, in comparison to other asset classes are presented. The three formed hypotheses are tested in subchapters 6.1, 6.2 and 6.3. The risk-adjusted performances of asset classes are examined in subchapter 6.1, while subchapter 6.2 presents the results for inflation hedging properties of observed asset classes. Lastly, optimal portfolio with fine wine investments is evaluated in subchapter 6.3.

As Liv-ex Fine Wine Investables -index is originally denoted in GBP, figure 4 shows the price development of the index in GBP and USD from January 1988, when the index was launched, until the end of 2018. Over the time period, in nominal GBP terms, the index has increased a total of 1663.06%, while in USD, the increase is 1001.44%. Before the financial crisis GBP was strong in relation to USD, however, as the financial crisis had a severe impact on the British banking system, GBP weakened rapidly in relation to USD, which caused USD denoted Liv-ex price to decrease more compared to GBP denoted price during the financial crisis. Hereinafter, USD denoted Liv-ex Fine Wine Investables -index is used to achieve comparable results.

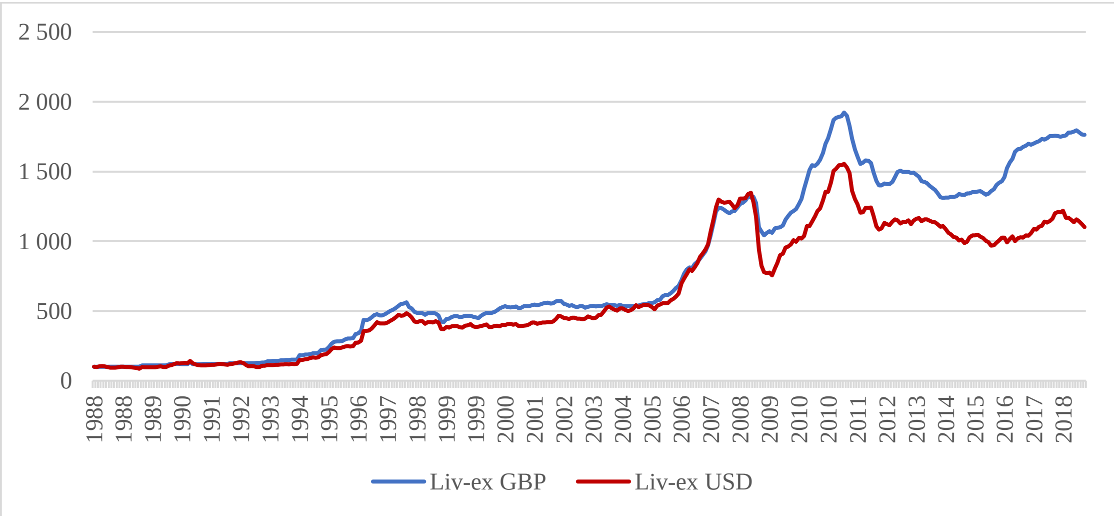

Figure 4. Liv-ex price development GBP vs USD.

Figure 5 expresses the price development for Liv-ex Fine Wine Investables -index in nominal terms and in inflation-adjusted terms. Over the 30-year period, the total return of the index in real terms is 412.39%. The figure shows three strong bullish periods. The first period from February 1993 to October 1997, when the real return was 341.45% and on average 36.70% annually. The second period lasted approximately three years from July 2005 to June 2008, when the total price increase was 135.26%, equal to 33.00% annually on average. The impact of the financial crisis can be seen between July 2008 and March 2009, when the index decreased 42.00% after which the third strong bullish began. Over the observed time period, the index reached its peak in 2011, when the index had increased 95.24% between March 2009 and June 2011.

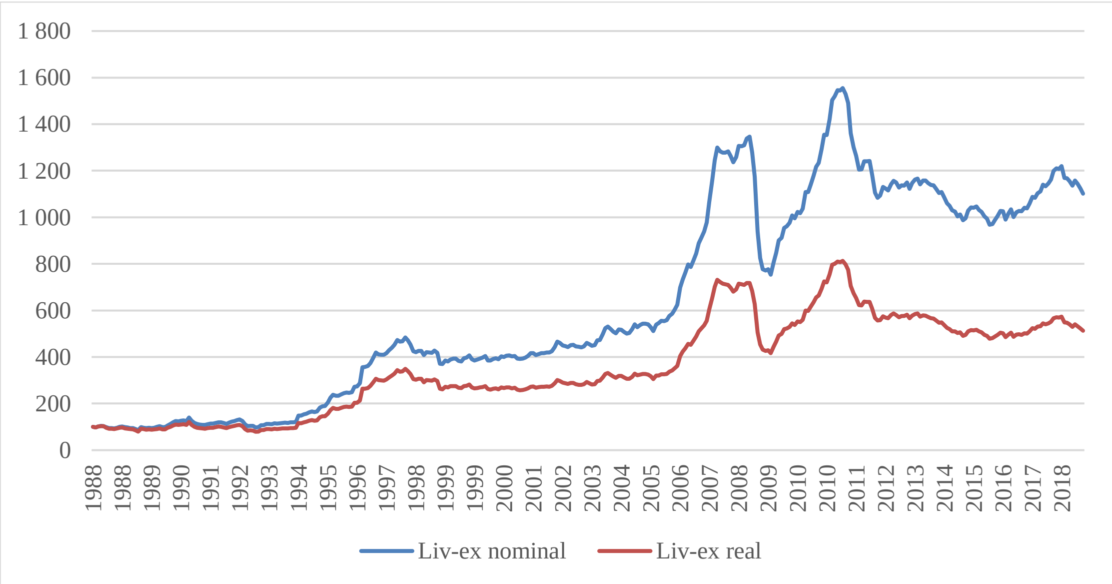

Figure 5. Liv-ex nominal vs real price development.

Figure 6 plots the inflation-adjusted price development of all observed asset classes. As the figure shows, the real return for S&P 400-index is the highest with 570.25% total return, which equals an annual average of 6.55%, while the return for Liv-ex Fine Wine Investables -index is second highest with 412.39% and 5.60% annually. The return for bonds is the third highest with 236.65%, corresponding 4.13% average yearly return. The returns for S&P 500 and Russell 2000 indices are 225.42% and 215.04% respectively. On average, the yearly return for S&P 500 is 4.01% and for Russell 2000 the return is 3.90%. An investment in 1-month LIBOR, which is considered as risk-free investment in this study, provide a return of 29.58% in total and 0.87% on average over the observed time period. Gold and MSCI world excluding USA indices are the only investments with negative real returns -10.82% for gold and -31.32% for MSCI world excluding USA. The average annual inflation-adjusted returns for gold and MSCI world excluding USA are -0.38% and -1.24% respectively. Nominal price development for all asset classes can be found from APPENDIX 2.

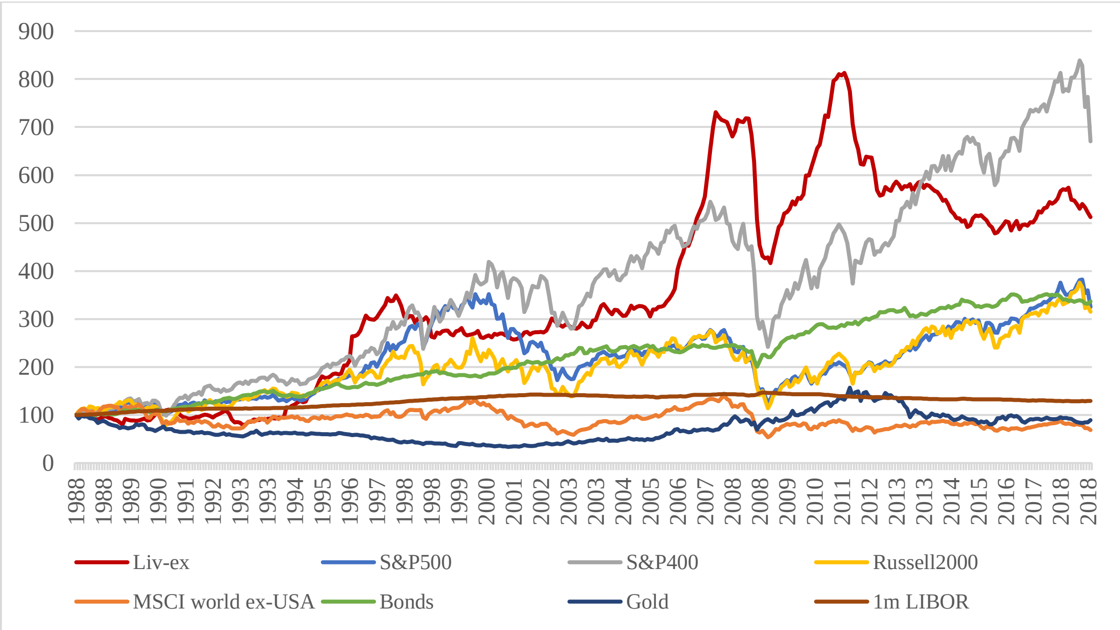

Figure 6. Real price development of asset classes.

6.1 Risk-adjusted performance

Risk-adjusted performance of different asset classes are evaluated using Sharpe ratio, Sortino ratio, value at risk and expected shortfall. Sharpe ratios and Sortino ratios are shown in table 2. In general, an investment can be considered as profitable, when Sharpe ratio or Sortino ratio is larger than 0, because the investment in question is then more profitable than risk-free investment. From the observed investments, bonds have the highest Sharpe ratio of 0.64, meaning, that bonds are the most profitable investments when standard deviation of excess returns is used as the measure for risk. S&P 400 have the second highest Sharpe ratio of 0.41 and Liv-ex Fine Wine Investables is the third highest with 0.40. Further, S&P 500 and Russell 2000 indices are more profitable than risk-free rate with ratios of 0.28 and 0.25 respectively. Gold investments are indifferent with the risk-free rate, while MSCI world excluding USA index is the only investment with a negative Sharpe ratio of -0.04, which means that investing in risk-free rate is preferred.

As Sharpe ratio defines both positive and negative deviations from the mean as risk, Sortino ratio classifies variation in only negative returns as risk. In line with the results from Sharpe ratio, bonds have the highest Sortino ratio as well. However, measured with Sortino ratio fine wine is more profitable than S&P 400, which indicates that there is a smaller probability of a large loss for fine wine compared to S&P 400. S&P 500 remains as the fourth most profitable investment with a ratio of 0.36 and the last profitable investment is Russell 2000 with 0.33 ratio. For both gold and MSCI world excluding USA, Sortino ratio provides same figures as Sharpe ratio. Overall, totally five of seven observed asset classes are more profitable, one is indifferent, and one is less profitable than the risk-free rate.

Table 2. Sharpe ratios and Sortino ratios.

	Liv-ex	S&P 500	S& P400	Russell 2000	MSCI world ex-USA	Bonds	Gold
Sharpe ratio	0.40	0.28	0.41	0.25	-0.04	0.64	0.00
Sortino ratio	0.57	0.36	0.52	0.33	-0.05	0.83	0.00

This table shows Sharpe ratios and Sortino ratios for all asset classes. The ratios are calculated from annualized figures.

Value at risk reports the best-case scenario of a given threshold from worst-case scenarios in the return distribution. Therefore, smaller VaR means lower risk for an investment.

Figure 7 shows 95% and 99% VaR for the indices included in this study. Looking at 95% VaR, bonds have the lowest value of -1.54%, which means that 5% of time, the loss when investing in bonds is larger than -1.54%. Fine wine has the second lowest VaR of -4.75%. Hence, on 95% confidence level, losses by investing in fine wine does not exceed -4.75%. Gold has the third lowest VaR of -6.46%, and as the descriptive statistics in chapter 4 shows, stocks have a larger volatility compared to other asset classes, and, therefore, stock indices exhibit largest VaR values. Consistent with theory regarding risk-return tradeoff, when comparing stock indices in USA, stock index for large companies, S&P 500 has the lowest VaR of -7.16%, while Russell 2000 index, which represent small companies, has the highest VaR of -8.49%, making Russell 2000 the riskiest investment of all observed asset classes. However, even though MSCI world excluding USA is an index for large companies, it has the second highest VaR of 8.35%. Figures for 99% VaR provide mostly similar results. Bonds remains as the least risky investment with -3.49% VaR, and fine wine the second least risky with a VaR of -11.05%. On 99% confidence level, S&P 500 surpassed gold as third least risky investment, while the ordering for the riskiest investments stays the same compared to 95% VaR.

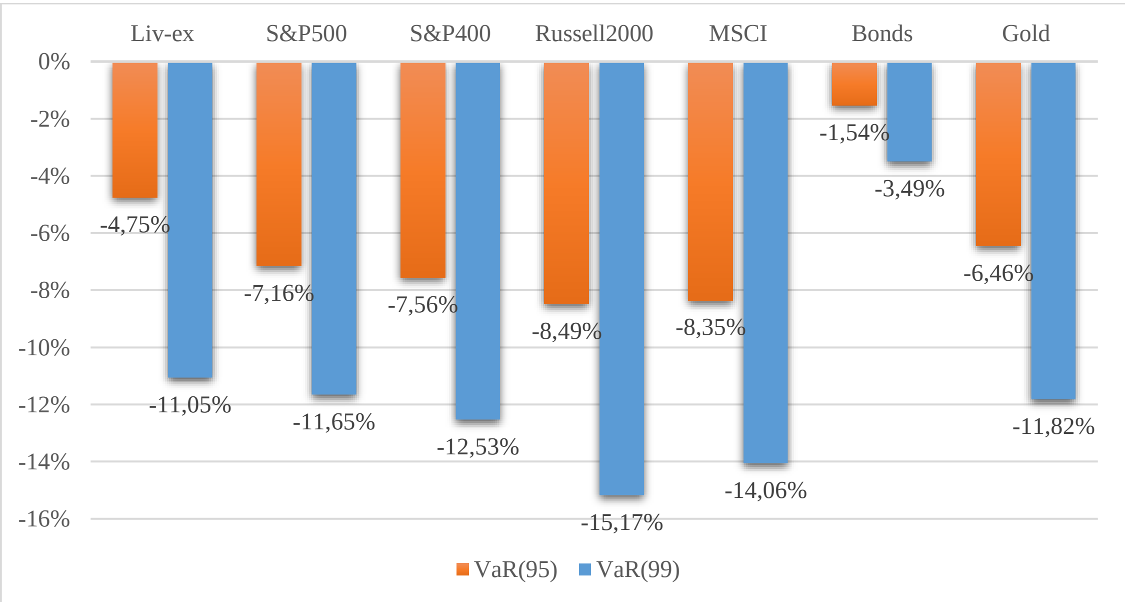

Figure 7. 95% and 99% value at risk.

Expected shortfall calculates expected loss for a given confidence level. Compared to VaR, ES provides more accurate results, when results are not normally distributed. Figure 8 shows the results for 95% and 99% ES. Similar to results obtained from VaR, bonds are the least risky investment also, when measured with ES. On 95% confidence level, the expected loss for bonds is -2.90% and -6.13% on 99% level. Fine wine has the second lowest ES with an average loss of -8.11% on 95% level and -14.66% on 99% level. Gold has the third lowest average loss of -9.45% on 95% ES, while stock indices seem to exhibit highest risk, with Russell 2000 having the highest ES of -12.70%. As with VaR, gold seem to have larger extreme negative returns relative to S&P 500, since 99% ES for S&P 500 is lower compared to gold. For Russell 2000, the expected loss for 1% of the time is over a fifth of the index value. S&P 400 is the second riskiest investments, while MSCI world excluding USA is the third riskiest with 99% ES of -19.11% and -18.27% respectively.

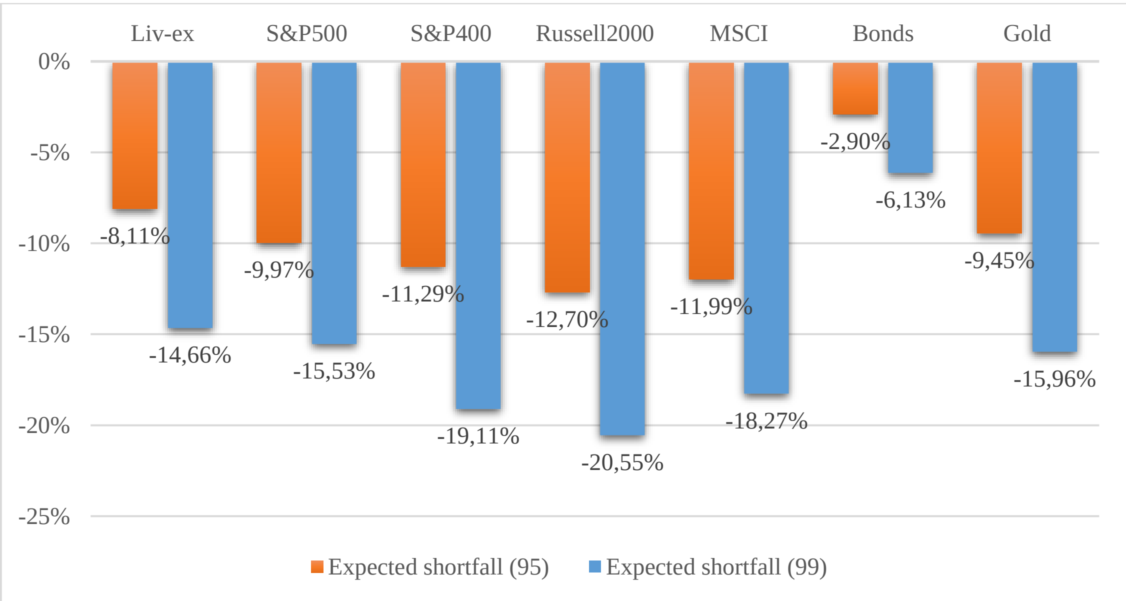

Figure 8. 95% and 99% expected shortfall.

6.2 Inflation hedging

The inflation hedging properties of asset classes are tested with linear regression models. Before running the model in equation 13, as the data is time-series, it is necessary to check if the data is stationary. Figure 9 shows the dot plot of the time-series data. In order to data being stationary, the mean should be around zero and there should be no trends, cycles or random walks. As the figure shows, the probability for non-stationarity is small in all other asset classes, except for 1-month LIBOR in the bottom right corner of the figure, which seems to be non-stationary.

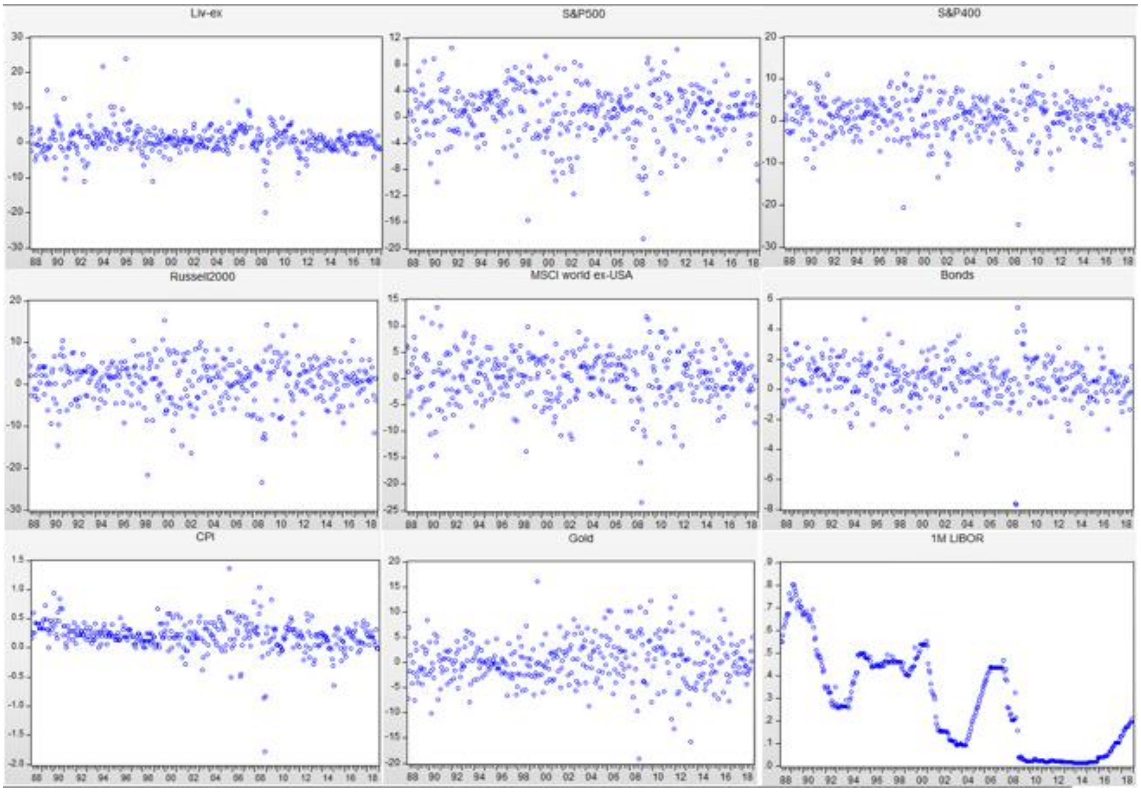

Figure 9. Dot plot of the time-series data.

Augmented Dickey-Fuller (ADF) test is used to confirm the suspicion. In case the t-statistic in ADF test is statistically significant, the null hypothesis, that the data is non-stationary, can be rejected. As table 3 shows, all other variables are statistically significant, and, therefore, stationary, except 1-month LIBOR. Since the data for 1-month LIBOR is non-stationary, the data needs to be differentiated. As 1-month LIBOR is already stated in percentages, the data is transformed as follows:

(19) $\Delta LIBOR_t = LIBOR_t - LIBOR_{t-1}$

Table 3. Augmented Dickey-Fuller unit root test.

Liv-ex	S&P 500	S&P 400	Russell 2000	MSCI world ex-USA	Bonds	Gold	CPI	1M LIBOR
-13.69*** (0.00)	-18.31*** (0.00)	-17.38*** (0.00)	-17.46*** (0.00)	-17.83*** (0.00)	-15.82*** (0.00)	-21.60*** (0.00)	-11.88*** (0.00)	-1.36 (0.60)

The table presents t-statistics of the Augmented Dickey-Fuller test. ***, ** and * represent statistical significance on 1%, 5% and 10%, respectively. P-values are reported in the parentheses.

The dot plot and ADF test for differentiated 1-month LIBOR data can be seen from APPENDIX 3. After all variables are stationary, the regression model can be run. Table 4 presents the results from the regression in equation 13. For an investment to be considered as a partial hedge against expected inflation, a statistically significant slope coefficient for CPI should be between 0 and 1 and for complete hedge, the statistically significant coefficient should be over 1. From all asset classes, fine wine (4.22), gold (1.56) and 1-month LIBOR (0.01) have statistically significant coefficients for expected inflation. However, 1-month LIBOR can only be considered as partial hedge since the coefficient is almost 0. Further, gold seems to offer complete hedge against expected inflation, however, at 10% significance level, when on 1% significance level, fine wine is the only asset class, which can be considered complete hedge against expected inflation. Lastly, as the size of R^2 indicates, there are several other relevant factors, other than inflation rate, which explain the returns for all asset classes.

Table 4. Regression results for hedging expected inflation.

	Liv-ex	S&P 500	S& P400	Russell 2000	MSCI world ex-USA	Bonds	Gold	1M LIBOR
Intercept	-0.16 (0.51)	0.58** (0.04)	0.77** (0.02)	0.62* (0.08)	0.09 (0.77)	0.63*** (0.00)	-0.05 (0.87)	-0.00** (0.03)
CPI	4.22*** (0.00)	0.17 (0.84)	0.32 (0.74)	0.22 (0.84)	0.64 (0.51)	-0.41 (0.17)	1.56* (0.08)	0.01** (0.01)
R^2	0.08	0.00	0.00	0.00	0.00	0.01	0.01	0.02
Adjusted R^2	0.08	-0.00	-0.00	-0.00	-0.00	0.00	0.01	0.01
Number of observations	371	371	371	371	371	371	371	371

Liv-ex, S&P 500, S&P 400, Russell 2000, MSCI world ex-USA, Bonds and Gold are dependent variables and the independent variable is CPI. The p-value is reported in parentheses, and ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

To control for the possibility that the returns of assets might respond with a lag to changes in inflation, and to examine the hedging properties of assets to unexpected inflation, regression model in equation 14 is run, which includes a lagged variable for expected inflation and a variable for unexpected inflation. The results are presented in table 5. As the table shows, stocks or bonds seem to not provide a hedge for either expected or unexpected inflation, since there are no positive statistically significant coefficients. Different to results in table 4, by using a lagged variable for expected inflation, only fine wine seems to hedge completely with a coefficient of 4.49, which is statistically significant at 1% level, whereas 1-month LIBOR provides partial hedge with a coefficient of 0.02.

For unexpected inflation, the slope coefficients for fine wine and gold are 4.01 and 3.06 respectively, both statistically significant at 1% level, and thus, showing evidence of a complete hedge against unexpected inflation. For bonds, even though not highly statistically significant, the coefficients are negatively related to both expected and unexpected inflation. The reason might be that the current inflation contains such information regarding future inflation expectations, which affect nominal expected future returns of bonds, since in case expected future inflation rate increases, bond prices decreases. Stocks appear to not hedge against either expected nor unexpected inflation. In general, when expected inflation is measured with a lagging variable, fine wine is the only asset class that looks to hedge completely against inflation, since both expected and unexpected variables are statistically significant at 1% level, and the coefficients are above 1.

Table 5. Regression results for expected and unexpected inflation.

	Liv-ex	S&P 500	S& P400	Russell 2000	MSCI world ex-USA	Bonds	Gold	1M LIBOR
Intercept	-0.21 (0.43)	0.56* (0.06)	0.80** (0.02)	0.68* (0.08)	0.36 (0.30)	0.67*** (0.00)	0.40 (0.21)	-0.00*** (0.01)
Expected inflation	4.49*** (0.00)	0.23 (0.81)	0.11 (0.92)	-0.19 (0.88)	-0.72 (0.53)	-0.61* (0.08)	-0.46 (0.66)	0.02*** (0.00)
Unexpected inflation	4.01*** (0.00)	0.12 (0.89)	0.50 (0.64)	0.54 (0.65)	1.68 (0.12)	-0.25 (0.44)	3.06*** (0.00)	0.01 (0.14)
R^2	0.08	0.00	0.00	0.00	0.01	0.01	0.04	0.03
Adjusted R^2	0.07	-0.00	-0.00	-0.00	-0.01	0.00	0.04	0.02
Number of observations	370	370	370	370	370	370	370	370

Liv-ex, S&P 500, S&P 400, Russell 2000, MSCI world ex-USA, Bonds and Gold are dependent variables and the independent variables are expected inflation and unexpected inflation. The p-value is reported in parentheses, and ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

6.3 Optimal portfolio with fine wine investments

To examine the potential of fine wine in portfolio diversification, it is necessary to analyse the correlation with traditional asset classes. Table 6 presents the correlation matrix for assets included in this study. For portfolio diversification, it is beneficial if the correlation coefficients for assets in the portfolio are negative or close to 0. As the table shows, fine wine has a relatively low correlation with all other asset classes, and, therefore, could be beneficial for portfolio diversification. The highest coefficient of 0.24 is with the international stock index, MSCI world excluding USA. Between the returns of fine wine and Russell 2000 index, there is no significant relationship. With all other asset classes, the correlation varies between 0.09 and 0.14. Bonds have a significant relationship with all asset classes, however, with a relatively small correlation, while gold show significant but low correlation with fine wine, bonds and international stocks. Stock indices show strong relationship between each other, while 1-month LIBOR seem to not be correlated with traditional asset classes.

Table 6. Correlation matrix.

	Liv-ex	S&P 500	S&P 400	Russell 2000	MSCI world ex-USA	Bonds	Gold	1M LIBOR
Liv-ex	1.00 -							
S&P 500	0.14*** (0.01)	1.00 -						
S&P 400	0.11** (0.04)	0.90*** (0.00)	1.00 -					
Russell 2000	0.06 (0.23)	0.81*** (0.00)	0.92*** (0.00)	1.00 -				
MSCI world ex-USA	0.24*** (0.00)	0.75*** (0.00)	0.70*** (0.00)	0.66*** (0.00)	1.00 -			
Bonds	0.14*** (0.01)	0.30*** (0.00)	0.28*** (0.00)	0.20*** (0.00)	0.29*** (0.00)	1.00 -		
Gold	0.09* (0.09)	-0.06 (0.28)	0.00 (1.00)	0.01 (0.85)	0.13** (0.01)	0.18*** (0.00)	1.00 -	
1M LIBOR	0.10* 0.06	0.02 0.65	0.18 0.73	-0.02 0.65	-0.01 0.79	0.05 0.36	-0.07 0.15	1.00 -

This table presents the correlation matrix among asset classes. The numbers in parentheses are p-values. *, **, *** denote statistical significance at the 10, 5 and 1% levels, respectively.

The next step in the analysis is to calculate the minimum variance portfolio and derive the efficient frontier without fine wine and with fine wine. The efficient frontiers, along with the capital allocation lines (CAL) are plotted in figure 10. In the figure x axis presents the annualized standard deviation, while y axis denotes the annualized returns. The efficient frontiers begin from the bottom left corner with the minimum variance portfolio, which consist of 1-month LIBOR (98.20%), bonds (1.07%) and gold (0.53%). In case a portfolio would be below or to the right of this point, the portfolio would not be considered efficient, since it is possible to obtain a higher level of return with lower or same level of risk. Efficient frontier ends to the point, where the highest possible return can be obtained, i.e. by investing 100% in S&P 400 index, since the expected return on mid cap companies is the highest among the examined asset classes. All the portfolios lying in the red efficient frontier are portfolios, which have the highest possible return for a given level of risk, when fine wine investments are not included in the asset allocation. The blue line represents efficient frontier with fine wine investments. The figure shows that the efficient frontier with fine wine is higher than the efficient frontier without fine wine, which means that it is possible to obtain a higher level of return with a lower level of risk by adding fine wine to the investment portfolio.

The straight yellow line in figure 10 denotes the capital allocation line for portfolios with fine wine investments and the yellow square represents the portfolio, which is tangent to the efficient frontier. The tangency portfolio is the optimal portfolio in the risk-return space. From all possible portfolios, the optimal portfolio has the highest Sharpe ratio, which is also the slope of the capital allocation line. The Sharpe ratio for the optimal portfolio with fine wine investments is 0.78 and the portfolio consist of bonds (74.47%), fine wine (15.60%) and mid cap stocks (9.93%).

The straight green line is the capital allocation line for portfolios without fine wine investments and the green triangle represents the tangency portfolio. The portfolio consists of bonds (87.99%) and mid cap stocks (12.01%) and the Sharpe ratio for this portfolio is 0.72, which is lower when compared to asset allocation, where fine wine is included. Comparing both optimal portfolios to individual assets, as supposed to, both portfolios have higher Sharpe ratio than any of the individual investments, which shows the effect of diversification. As bonds have the highest Sharpe ratio, majority is invested in bonds in both portfolios. However, in the optimal portfolio with fine wine investments, a larger proportion is invested to fine wine compared to mid cap stocks, even though the Sharpe ratio for S&P 400 is higher than the Sharpe ratio for fine wine, which can be at least partially explained by the low correlation fine wine has with the other asset classes.

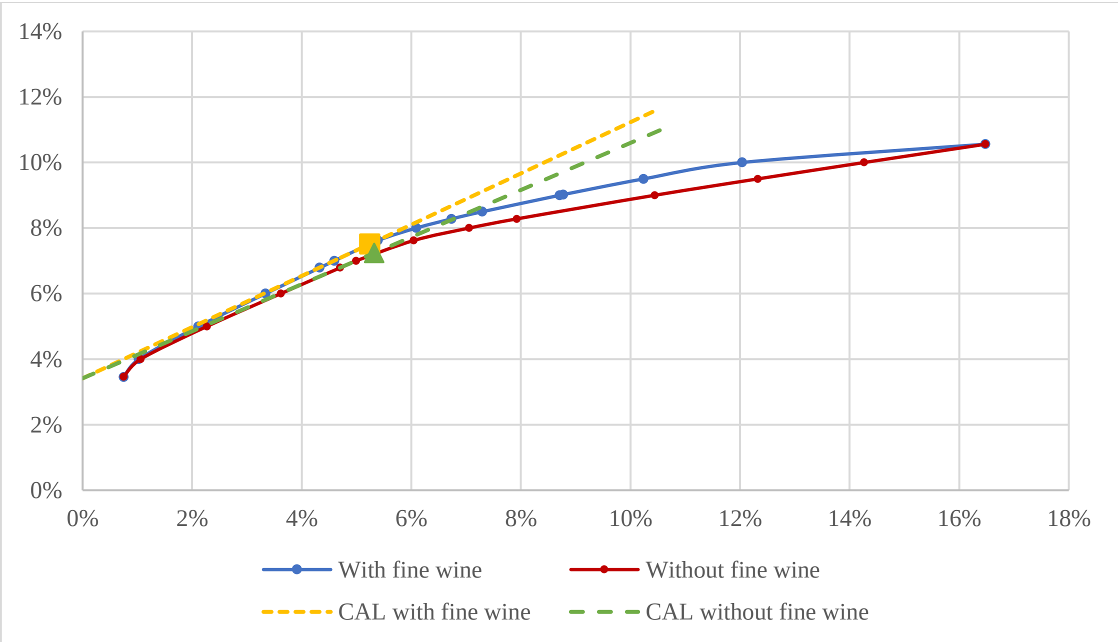

Figure 10. Efficient frontiers and CALs with fine wine and without fine wine.

6.4 Robustness check

The presented results are tested for robustness in this subchapter. The robustness check is conducted by dividing the sample into two subsamples so, that the first subsample examines a time period from January 1988 to June 2003, while the second subsample covers the remaining part, from July 2003 to December 2018. As previous literature suggests that the research results regarding fine wine investing can be dependent of the time period of the study, dividing the whole sample into two subsamples makes it is possible to observe the possibility, that the results are sample-specific.

Panel A in Table 7 shows the risk-adjusted performance measures for the first subsample, while the results for the second subsample are presented in Panel B. The two subsamples provide somewhat similar results for fine wine investing when compared to the original results. Compared to stocks, the Sharpe and Sortino ratios are higher for fine wine investments, with the exception that the Sharpe ratio for S&P 400 in the first subsample is higher than the Sharpe ratio for fine wine. Gold, on the other hand, provide the most deviating results, as the Sharpe and Sortino ratios are the lowest of all asset classes in the first subsample, but in the second sample, the Sharpe ratio for gold is the fourth highest and the Sortino ratio is the second highest. As the robustness check for VaR and ES do not either differ significantly from the original results, it can be stated that the original findings for fine wine investments are robust, in terms of risk-adjusted performance.

Table 7. Robustness check with risk-adjusted performance measures.

	Liv-ex	S&P 500	S&P 400	Russell 2000	MSCI world ex-USA	Bonds	Gold
Panel A: January 1988-June 2003							
Sharpe ratio	0.39	0.23	0.42	0.16	-0.19	0.77	-0.56
Sortino ratio	0.66	0.33	0.57	0.22	-0.28	1.30	-0.95
95% VaR	-5,03 %	-7,01 %	-7,54 %	-8,58 %	-8,25 %	-1,46 %	-5,86 %
99% VaR	-11,05 %	-12,27 %	-14,46 %	-17,24 %	-13,93 %	-2,52 %	-8,16 %
95% ES	-8,06 %	-10,10 %	-11,20 %	-13,38 %	-11,59 %	-2,10 %	-7,69 %
99% ES	-11,96 %	-14,82 %	-18,41 %	-20,62 %	-15,40 %	-2,76 %	-9,69 %
Panel B: July 2003-December 2018							
Sharpe ratio	0,41	0,34	0,40	0,34	0,12	0,53	0,39
Sortino ratio	0,49	0,39	0,46	0,43	0,14	0,60	0,58
95% VaR	-4,58 %	-7,37 %	-7,58 %	-8,38 %	-8,89 %	-1,64 %	-7,56 %
99% VaR	-13,27 %	-12,61 %	-13,93 %	-14,56 %	-16,93 %	-7,63 %	-16,17 %
95% ES	-8,62 %	-10,57 %	-12,14 %	-12,90 %	-13,23 %	-3,84 %	-11,70 %
99% ES	-17,35 %	-16,24 %	-19,80 %	-19,66 %	-21,12 %	-8,22 %	-18,70 %

This table reports risk-adjusted performance measures for two subsamples. Panel A reports the performance measures over a period from January 1988 to June 2003 and Panel B reports performance measures from July 2003 to December 2018.

The robustness check for inflation hedging show evidence of fine wine providing varying results over different time periods. Table 8 shows the robustness check for inflation hedging for the two subsamples. Panel A presents the regression results for the first subsample, while the results for the second subsample are shown in Panel B. For fine wine, the results from the first subsample indicate that, even though the coefficients for both expected and unexpected inflation are above 1, fine wine has no significant inflation hedging properties, whereas the result from the second subsample suggest the opposite, as both expected and unexpected inflation have highly statistically significant coefficients, which are higher than 1.

The results for stocks are also dependent on the time period, as in general, stocks seem to have a negative relationship with both expected and unexpected inflation in the first subsample, while in the second subsample, mid cap, small cap and international stocks seem to have potential in hedging against unexpected inflation. One potential explanation could be that previously, market might have been inefficient in transferring the available information regarding inflation into stock prices. In line with the original results, bonds, even though not significantly, mostly exhibit negative relationship with inflation. For both subsamples, consistent with the original results, gold seem to hedge against unexpected inflation. The inflation hedging potential for 1-month LIBOR have increased, since the results show partial hedging properties for the second subsample. Overall, the robustness check for inflation hedging indicate that the results can be different for different time periods, especially for fine wine and stocks.

Table 8. Robustness check for inflation hedging.

	Liv-ex	S&P 500	S&P 400	Russell 2000	MSCI world ex-USA	Bonds	Gold	1M LIBOR
Panel A: January 1988-June 2003								
Expected inflation	1.26 (0.55)	-3.85* (0.07)	-4.90** (0.04)	-6.60** (0.01)	-6.83*** (0.00)	-0.07 (0.92)	-0.79 (0.65)	0.01 (0.59)
Unexpected inflation	1.02 (0.57)	-3.75** (0.04)	-4.52** (0.03)	-4.86** (0.03)	-2.60 (0.20)	-0.15 (0.79)	2.48* (0.10)	-0.01 (0.49)
Panel B: July 2003-December 2018								
Expected inflation	5.51*** (0.00)	1.46 (0.18)	1.56 (0.24)	1.86 (0.21)	1.31 (0.32)	-0.98** (0.02)	0.06 (0.97)	0.02*** (0.00)
Unexpected inflation	5.16*** (0.00)	1.53 (0.15)	2.30* (0.07)	2.47* (0.08)	3.22** (0.01)	-0.31 (0.44)	3.49** (0.01)	0.01*** (0.01)

Liv-ex, S&P 500, S&P 400, Russell 2000, MSCI world ex-USA, Bonds, Gold and 1M LIBOR are dependent variables and the independent variables are expected inflation and unexpected inflation. The p-value is reported in parentheses, and ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

For optimal portfolio, the results are robust across both subsamples. The results indicate that fine wine investments in a portfolio increases portfolio performance in both subsamples. In the first subsample, the optimal portfolio with fine wine has a Sharpe ratio of 0.95, while the Sharpe ratio for portfolio without fine wine is 0.87. In the optimal portfolio for the first subsample, 13.01% is allocated to fine wine, while 8,79% and 78.20% are allocated to mid cap stocks and bonds, respectively. In the second subsample, the optimal portfolio consists of fine wine (17.40%), mid cap stocks (9.29%), small cap stocks (1.25%), bonds (60.09%) and gold (11.97%), with a Sharpe ratio of 0.70. The Sharpe ratio for the portfolio without fine wine in the second subsample is 0.67.

7 CONCLUSIONS

This study examines fine wine as an investment. To investigate the investment potential of fine wine, the performance of fine wine is compared to traditional asset classes, i.e. stocks, bonds and gold, by both in terms of raw return as well as risk-adjusted return. Further, the diversification potential of fine wine is analysed by first observing the inflation hedging properties of fine wine along with other asset classes, and lastly, by constructing efficient frontier with and without fine wine investments and finding the optimal portfolio with fine wine.

Over a 30-year period, the raw returns of fine wine have exceeded those received from bonds, gold and stocks, except for mid cap stocks. Thus, as the results in previous research papers have been somewhat dependent on the time period of the paper, the findings in this study regarding raw return supports the findings by Bouri, Gupta, Wong & Zhu (2018), Masset et al. (2010a) and Dimson et. al. (2015). On a risk-adjusted basis, fine wine is more attractive investment compared to stocks and gold, since fine wine has higher Sortino ratio and smaller losses when measured with value at risk and expected shortfall. Although, measured with Sharpe ratio, S&P 400 index outperforms fine wine. In addition, bonds outperform fine wine in risk-adjusted terms in all risk-adjusted performance measures, and, therefore, the first hypothesis of wine outperforming all other asset classes cannot be accepted. Even though fine wine does not outperform all of the asset classes, and purely considering mean and variance, as the modern portfolio theory does, the comparable rate of return combined with relatively low standard deviation makes fine wine an attractive option for investors, who are looking for new investment opportunities.

Whereas stocks do not show indications of inflation hedging properties over the 30-year time period, gold and especially fine wine seem to offer hedge against both expected and unexpected inflation, thus, providing similar findings as Bodie (1983). Therefore, both fine wine and gold could provide diversification benefits to a portfolio. A potential explanation for the inflation hedging properties of fine wine could be, as mentioned in theory section, the increased demand especially in the emerging markets, since the increasing demand usually increase the price of the commodity used to produce the good. Since fine wine appears to hedge against inflation, the second hypothesis formed for this paper can be accepted. However, as the robustness check indicates, and the contradicting findings by Krasker (1979) and Jaeger (1981) suggest, it is necessary to emphasize that the results can be sample-specific and highly dependent on the time period of the study.

Similar to findings by Masset & Henderson (2010b), this study records low correlation between fine wine and other asset classes. Therefore, it can be possible to decrease the portfolio risk, without decreasing the expected return. Furthermore, in line with results by Aytaç et. al. (2016) and Bouri et. al. (2018), compared to a portfolio, where fine wine is not included, the efficient frontier for portfolio with fine wine is higher, which means that wine investments in a portfolio increase portfolio performance. Hence, the third hypothesis can be accepted. For the optimal portfolio in this thesis, 74.47% is allocated to bonds while 15.60% is allocated to fine wine and 9.93% to mid cap stocks, and the Sharpe ratio for the portfolio is 0.78.

The practical implication of this study is that fine wine could have a vital role in portfolio diversification, since investors can achieve same rate of return with lower risk, or higher rate of return with same level of risk by including fine wine investments in the asset allocation. In line with findings by Sanning et. al. (2008), the results in this paper suggest, that fine wine can be profitable investment both alone and as a part of a diversified portfolio. However, even though the taxation is lighter for fine wine investing, as Dimson & Spanjers (2014) and Veld & Veld-Merkoulova (2007) show in their studies with other collectibles, it is important to highlight the effect of costs, which can be considerably higher for fine wine investing compared to e.g. stock investments. Further, even though fine wines from Bordeaux region are relatively frequently traded, the fine wine market in general is fairly illiquid compared to traditional financial markets, hence, investors expect a higher premium for illiquidity risk. Also, this study was conducted using Liv-ex Fine Wine Investables -index, which is regarded as industry benchmark, but trading the index is not possible. Instead, fine wine can only be traded by methods described in the theory section. Therefore, the risk and return characteristics presented in this paper should be interpreted as indicative.

As the number of previous studies regarding fine wine in the field of finance is relatively low, analysing the performance and impact of costs between different methods of investing in fine wine could be a potential subject for future research. That would provide valuable information regarding the cost structure and return characteristics between different methods, since mostly previous literature use Liv-ex or other indices for analysing the fine wine market. In addition, wine stocks, despite not being classified as fine wine investment, could be included in the analysis. Moreover, as this thesis, along with most of the previous literature, study Bordeaux wine, a more comprehensive study regarding other wine regions would provide better insight regarding the performance of the whole industry. For example, in addition to other French regions, such as Burgundy and Rhône, the study could include top wines from all over the world. Moreover, due to the relatively low liquidity, a closer look into the illiquidity premium associated with fine wine could be useful. Lastly, as this paper conduct the portfolio optimization using the classical mean-variance approach, which has several underlying assumptions, the portfolio optimization could be performed using an alternative approach. One possibility could be the Black-Litterman approach, which tries to solve the problems of estimating the expected returns and the weight sensitivity of the different assets to small changes in expected returns.

LIST OF REFERENCES

Ali, H., S. Lecocq & M. Visser (2008). The impact of gurus: Parker grades and en primeur wine prices. *The Economic Journal* 118, F158 – F173.

Ali, H. & C. Nauges (2007). The Pricing of Experience Goods: The Example of en premieur wine. *American Journal of Agricultural Economics* 89, 91 – 103.

Ashenfelter, O. (2008). Predicting the Quality and Prices of Bordeaux Wine. *The Economic Journal* 118, F174 – F184.

Aytaç, B., H. Thi-Hong-Van & C. Mandou (2016). Wine: To drink or invest in? A study of wine as an investment asset in French portfolios. *Research in International Business and Finance* 36, 591 – 614.

Bodie, Z. (1983). Commodity futures as a hedge against inflation. *The Journal of Portfolio Management* 9, 12 – 17.

Bodie, Z., A. Kane & A.Marcus (2014). *Investments.* 10th edition. New York: McGraw-Hill Education. ISBN 978-0-07-786167-4.

Bouri, E., R. Gupta, W-K. Wong, Z. Zhu (2018). Is wine a good choice for investment? *Pacific-Basin Finance Journal* 51, 171 – 183.

Burton, B., & J. Jacobsen (2001). The rate of return on investment in wine. *Economic Inquiry* 39, 337 – 350.

Campbell, R. A. J. (2008). Art as a Financial Investment. *The Journal of Alternative Investments* 10, 64 – 81.

Canner, N., N. Mankiw & D. Weil (1997). An asset allocation puzzle. *American Economic Review* 87, 181 – 191.

Carhart, M. (1997). On Persistence in Mutual Fund Performance. *The Journal of Finance* 52, 57 – 82.

Chua, J. & R. S. Woodward (1982). Gold as an inflation hedge: A comparative study of six major industrial countries. *Journal of Business Finance & Accounting* 9, Issue 2, 191 – 197.

Clarke, O. (1999). Oz Clarke's new encyclopedia of wine. London. Websters International Publishers Limited.

della Casa, A. & C. Smith (2009). Fine returns from fine wine. *Professional Adviser.* [online] [cited 2018-11-25]. Available from the internet: <https://search-proquest-com.proxy.uwasa.fi/abicomplete/docview/220887448/fulltextPDF/3566670A346847AFPQ/2?accountid=14797>.

Dimson, E., P. Rousseau & C. Spaenjers (2015). The price of wine. *Journal of Financial Economics* 118, 431 – 449.

Dimson, E. & C. Spaenjers (2014). Investing in Emotional Assets. *Financial Analysts Journal* 70, 20 – 25.

Erb, C. & H. Campbell (2006). The Strategic and Tactical Value of Commodity Futures. *Financial Analysts Journal* 62, Number 2, 69 – 97.

European Commission. (2001). *Risk Management Tools for EU Agriculture with a special focus on insurance.* Working Document, Agriculture Directorate-General. [online] [cited 2018-12-2]. Available from the internet: <https://ec.europa.eu/agriculture/publi/insurance/text_en.pdf>.

Fama, E. & K. French (1993). Common Risk Factors in the Returns on Stocks and Bonds. *Journal of Financial Economics* 33, 3 – 56.

Fama, E. & K. French (2015). A five-factor asset pricing model. *Journal of Financial Economics* 116, 1 – 22.

Fama, E. & G. Schwert (1977). Asset returns and inflation. *Journal of Financial Economics* 5, 115 – 146.

Fogarty, J. (2007). Rethinking Wine Investment in the UK and Australia. American Association of Wine Economists. *AAWE Working Paper* No. 6.

Gorton, G. & G. Rouwenhorst (2006). Facts and Fantasies about Commodity Futures. *Financial Analysts Journal* 62, Number 2, 170 – 191.

ICE Benchmark Administration Limited (IBA) (2019a). *ICE BofAML US Corp Master Total Return Index Value*. Federal Reserva Bank of St. Louis: < https://fred.stlouisfed.org/series/BAMLCC0A0CMTRIV#0>.

ICE Benchmark Administration Limited (IBA) (2019b). *1-month London Interbank Offered Rate (LIBOR), based on U.S. dollar*. Federal Reserva Bank of St. Louis: <https://fred.stlouisfed.org/series/USD1MTD156N#0>.

ICE Benchmark Administration Limited (IBA) (2019c). *Gold Fixing Price 3:00 P.M. (London time) in London Bullion Market based in U.S. dollars*. Federal Reserva Bank of St. Louis: < https://fred.stlouisfed.org/series/GOLDPMGBD228NLBM#0>.

Jaeger, E. (1981). To Save or Savor: The Rate of Return to Storing Wine. *The Journal of Political Economy* 89, 584 – 592.

Karlsson, B. (2014). Vinlandet Frankrike–trend och tradition. Stockholm. Carlssons Bokförlag.

Karmavuo, R. & J. Lihtonen (2009). *Viini & ruoka–opas makujen harmoniaan*. 4th edition. Helsinki: Kustannusosakeyhtiö TEOS.

Kourtis, A., R. Markellos & D. Psychoyios (2012). Wine price risk management: International diversification and derivative instruments. *International Review of Financial Analysis* 30, 30 – 37.

Krasker, W. (1979). The Rate of Return to Storing Wines. *The Journal of Political Economy* 87, 1363 – 1367.

Liv-ex (2019a). *Pricing* [online]. Available from the internet: <https://www.liv-ex.com/membership/>.

Liv-ex (2019b). *The Liv-ex indices* [online]. Available from the internet: <https://www.liv-ex.com/2012/11/liv-ex-indices/>.

Liv-ex (2019c). *Indices* [online]. Available from the internet: <https://www.liv-ex.com/news-insights/indices/>.

Lucey, B & L. Devine (2015) Was wine a premier cru investment? *Research in International Business and Finance* 34, 33 – 51.

Markowitz, H. (1952). Portfolio Selection. *The Journal of Finance* 7, 77 – 91.

Masset, P. & J-P. Weisskopf. (2010a). Raise your Glass: Wine investment and the Financial Crisis. *American Association of Wine Economists.* Working Paper No. 57.

Masset, P. & C. Henderson. (2010b). Wine as an Alternative Asset Class. *Journal of Wine Economics* 5, 87 – 118.

Masset, P & J-P. Weisskopf. (2015). Wine Funds: An Alternative Turning Sour? *The Journal of Alternative Investments* 17 (4), 6 – 20.

Masset, P. & J-P. Weisskopf. (2018). Wine indices in practice: Nicely labelled but slightly corked. *Economic Modelling* 68, 555 – 569.

Meltzer, P. (2005). *Insuring Your Wine Collection* [online] [cited 2018-11-25]. Available from the internet: < https://www.winespectator.com/webfeature/show/id/Insuring-Your-Wine-Collection_3536>.

Moschini, G. & D. Hennessy. (1999). Uncertainty, Risk Aversion and Risk Management for Agricultural Producers. *Economic Staff Paper Series* 315.

MSCI (2019a). *MSCI World Ex USA Index* [online]. Available from the internet: <https://www.msci.com/documents/10199/99459e68-5e21-4888-ace6-72a3ffe9b1ab>.

Nuikki, P. (2015). In Vino veritas–Viinit keräilyn ja sijoittamisen kohteena. Helsinki. ReadMe.fi / Fine Publishing Ltd.

Pichery, M-C. & E. Giraud-Héraud. (2013). Wine Economics: Quantitative Studies and Empirical Applications. London. Palgrave Macmillan.

Pickup, O. (2015). Investing in wine: seven things you need to know. *The Telegraph* [online] [cited 2018-11-25]. Available from the internet: <http://www.telegraph.co.uk/foodanddrink/wine/11299838/Investing-in-wine-seven-things-you-need-to-know.html>.

Sanning, L., S. Shaffer & J. Sharratt. (2008). Bordeaux Wine as a Financial Investment. *Journal of Wine Economics* 3, 51 – 71.

Sotheby's. (2018a). Auctions. [online] Available from the Internet:

<http://www.sothebys.com/en/buysell/auctions.html>

Sotheby's. (2018b). Glossary. [online] Available from the Internet: <http://www.sothebys.com/en/Glossary.html>

The National Archives (1992). *Taxation of Chargeable Gains Act* [online]. Available from the internet: <http://www.legislation.gov.uk/ukpga/1992/12/section/44/enacted>.

Veld, C. & Y. Veld-Merkoulova (2007). Portfolio Diversification Benefits of Investing in Stamps. *The Journal of Alternative Investments* 10, 56 – 61.

Wine Investment. (2018a). *Storage & Provenance* [online]. Available from the internet: <http://www.wineinvestment.com/wine-investment/storage-and-provenance/>.

Wine Investment (2018b). *Tax considerations–Tax-Free Investments* [online]. Available from the internet: <https://www.wineinvestment.com/wine-investment/tax-advice/>.

Worthington A. & H. Higgs (2003). Art as an investment: Short and long-term comovements in major painting markets. *Empirical Economics* 28, 649 – 668.

APPENDIX 1. Nominal price development and returns of asset classes.

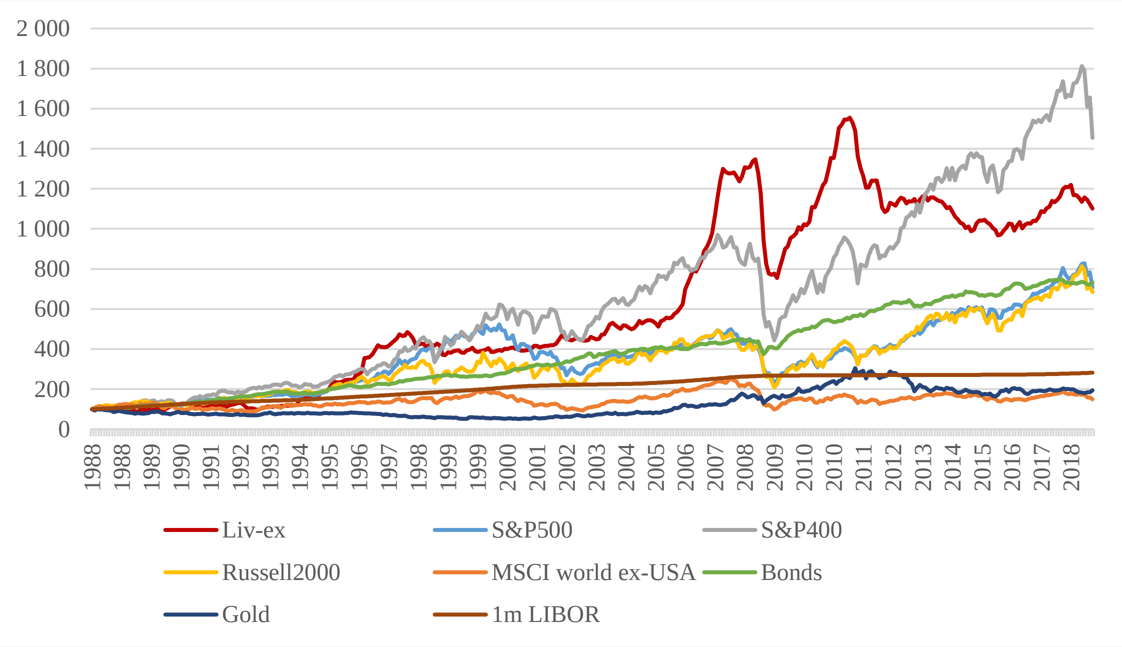

Figure 11. Nominal price development of asset classes.

Table 9. Nominal total and average return.

	Total nominal return	Average annual nominal return
S&P400	1353.74 %	9.33 %
Liv-ex	1001.44 %	8.33 %
Bonds	632.56 %	6.86 %
S&P500	607.37 %	6.74 %
Russell2000	584.81 %	6.62 %
1m LIBOR	182.11 %	3.52 %
Gold	93.72 %	2.23 %
MSCI world ex-USA	49.64 %	1.35 %

APPENDIX 2. ADF test for differentiated 1-month LIBOR data.

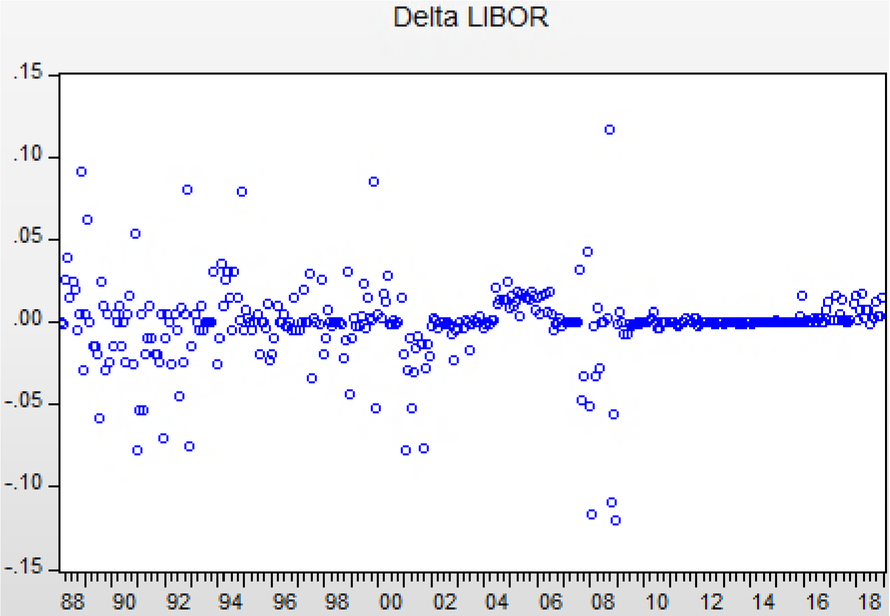

Figure 12. Dot plot for 1-month LIBOR after differentiating.

Table 10. ADF test for 1-month LIBOR after differentiating.

	t-Statistic	prob.
Augmented Dickey-Fuller test statistic	-8.40	(0.00)

The table presents t-statistic of the Augmented Dickey-Fuller test. ***, ** and * represent statistical significance on 1%, 5% and 10%, respectively. P-value is reported in the parentheses.