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To what extent do fine wines contribute to the performance of a portfolio? Research focused on the Californian territory

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Declaration of generative AI in scientific writing

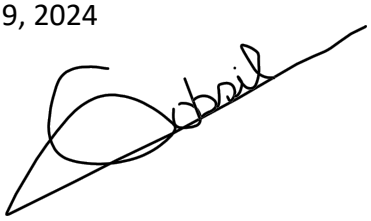
During the preparation of this master thesis, the author utilized ChatGPT and DeepL. ChatGPT was used as a help when the author struggled understanding some ideas and concepts from different sources. He also used it to detect spelling and grammatical errors. However, it has never been used to write, develop or make some computations, that are presented in this thesis. DeepL has been used as a help to translate some words or phrases, both when reading external resources and when writing the thesis.

After using this tool/service, the author diligently reviewed and edited the content by the tool. We take full responsibility for the final content presented in this thesis.

By signing this declaration, we affirm that the content of this master's thesis reflects our original work, augmented by the responsible use of AI.

Friday, August 9, 2024

Martin Absil,



Acknowledgement

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I also want to thank a friend for providing me with the different liv-ex indices from Bloomberg and suggesting using plotdigitizer.com to collect some data.

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I wish you an enjoyable reading!

Abstract

This thesis studies the contribution of fine wine assets, particularly Californian wines, to portfolio performance. Using data from January 2014 to January 2024, it compares Californian wine indices (Liv-ex California 50, CultX) with global fine wine indices (Liv-ex 100, Liv-ex Investables, Liv-ex 50) and traditional American assets (S&P 500, S&P MidCap 400, S&P Small Cap 600, MSCI World, and US 10-Year Treasury Bonds). The study evaluates the diversification benefits and risk-adjusted performance of these assets using Mean-Variance (Markowitz, 1952) and Mean-Modified Value-at-Risk (Favre and Galeano, 2002) optimizations, alongside Sharpe (1964) and Modified Sharpe Ratios (Gregoriou and Gueyie, 2003).

The findings demonstrate that including fine wine assets, especially Californian wines, improves portfolio efficiency by improving the efficient frontier, particularly for risk-averse investors. Californian wines show higher returns and lower correlations with traditional assets, making them strong candidates for diversification. Sharpe Ratio optimization suggests wine allocations ranging from 4% to 74%, while M-Sharpe Ratio maximization, which accounts for downside risk, recommends weights ranging between 3% and 72% for some investor profiles. These results highlight the favorable skewness and lower downside volatility of fine wine returns compared to traditional assets.

Californian wine assets outperformed global wine assets in the period studied, offering better risk-adjusted returns and portfolio diversification benefits. However, practical considerations such as storage costs, limited liquidity, and investment access remain some challenges for this alternative asset. However, despite these practical difficulties to invest in fine wine, this study underscores the potential of Californian fine wines as valuable alternative investments, offering attractive risk-adjusted returns and diversification when incorporated in an overall portfolio.

Keywords: Californian fine wine, wine investment, portfolio optimization, alternative assets, performance analysis, Sharpe Ratio, Modified Sharpe Ratio, Mean-Variance, Mean-Modified Value-at-Risk, investment diversification.

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1. Introduction:

Wine. Only one word but we can tell, you are already thinking of its colors, its bottles, its regions or even its “châteaux”. We also all have been surprised, or we can even say shocked to see at what price the most sought-after bottles are sold for. Taylor (2024) made a ranking of the most expensive wines ever sold; the winner is a bottle of Domaine de la Romanée-Conti 1945 that was sold for 558,000$ equivalent to 482,000€ in 2018. But the reason for such a high price can be explained not only by the prestige, social status, or personal satisfaction, this can also be done for economic reasons.
This is not new! Thanks to the advent of glass bottles and cork stopper, wine conservation took a new turn and allowed people to keep wine for longer periods of time. This was 150 years ago, in the 19th century, when the first investments in wines were made. (Aytaç et al., 2016)

Indeed, wine and investment are two words that can be linked together, and investing in this new kind of asset can generate positive returns. Several researchers have already written articles about this topic, we will take a deeper look later in the literature review. We can already say that things have changed a lot in the past 45 years. Krasker (1979) showed that wine returns were below the rate of return of riskless assets. This has been contradicted two years later by Jaeger (1981). Since then, different studies have been conducted, studying the volatility of wine assets (Burton & Jacobsen, 2001), the performance compared to bonds and equities (Dimson and al. 2015), the degree of diversification (Fogarty & Sadler, 2014), the impact of emerging countries on wine indices (Cardebat et al, 2018) or even studies on the efficiency of the fine wine market (Ameur et al., 2024). This will be developed more in the literature review.

Purchasing wine can be done in multiple ways. First, we can build our own wine storage by purchasing wine "en primeur", right after the harvest when it is still in barrels, or from vineyards in bottles. Secondly, wine auctions allow also consumers to purchase bottles. Moreover, we can make investments in wine investment companies that offer "turnkey"

cellar management services handled by experts or self-managed cellars. Another way to invest in wine is through wine investment funds, which work similarly to regular mutual funds. Each fund in this instance is essentially a portfolio made up of many wine varieties. Finally, an investor can purchase shares from a wine real estate investment organization. In this case, the investor purchases vineyard lots, which are thereafter managed by an experienced wine producer. In proportion to the stake they own in the wine real estate investment group, the investor acquires ownership of a portion of the vineyard.

The opportunity we have today, and it is something that can be seen easily, is that most of the studies introduced above, have been conducted with data coming from global wine indices that are mainly composed of French wines. Liv-ex 100 is composed of 77% of French wines to give an example. The goal of this study is to determine if the efficiency of wine assets can also be performed with fine Californian wine. The terms “efficiency” and “performance” incorporate here the returns, risk ratios and impact on a portfolio composed of other assets. We will compare the performance of Californian fine wines with other traditional assets, US Bonds and stocks. United States is growing more and more in terms of development of wine production thanks to the state of California and especially Napa Valley, that helps this growth thanks to its unique position, which we could believe was made for viticulture (Fagan, 2022). Indeed, according to Hira and Swartz (2014) entrepreneurship, global technology transfer, social capital and geographic location were some of the advantages the led Napa Valley to the industry success we know today and its prestige, much higher than in the rest of the United-States.

With the different financial drops financial markets have faced, due to the pandemic, the war in Ukraine or even with the Israeli-Palestinian conflict, we want to study another source of investment, something that, we believe, does not have a strong correlation with the traditional financial markets. Reading that a lot of research have been made with data of French fine wines, we wanted to focus our research on the Californian fine wine market, which, to the best of our knowledge, has not been studied before. Our research question is, *“To what extent do fine wines contribute to the performance of a portfolio? Research focused on the Californian territory*.”

If the Californian market has the same trends and assumptions that the rest of the world, more precisely, than the French wine markets, we can expect an improvement in the efficiency of portfolios when including Californian fine wines. Meaning the same rate of expected return would be associated with a lower risk, or vice versa, and finally, the correlation with the traditional financial market should not be strong which provides a more diversified portfolio (Aytac et al, 2016). It is important to note that these are assumptions of potential future findings, but we stay open-minded in case our results show otherwise.

To answer our research question and understand the trends of the Californian fine wine market, we will work with a 10-year data frame, splitting it into two different sets in order to perform an out-of-sample testing. By performing a Mean-Variance efficient frontier analysis, we can determine if including fine wine assets improves the frontier for a given level of risk and how. With this method, we discovered that an improvement could be made with this new asset, and it was more accentuated at a lower level of risk. Then, thanks to a Mean-Modified Value-at-Risk (M-MVaR) efficient frontier test, having the same goal as the Mean-Variance efficient frontier analysis but with a different method, we can see that higher returns can be reached at every level of risk by including Californian fine wine assets in the portfolio. Finally, we will dive into a Sharpe and M-Sharpe ratio maximization with different levels of risk willingness to evaluate the optimal weight to include in each portfolio. Results show that between 3% and up to 74% of the total investment could be allocated to fine wine investment, depending on the risk profile, the fine wine index being studied, and the methodology used. A deeper explanation and discussion about the results will be presented later in the thesis.

In the following sections of thesis, you will find in Section 2, more details about the literature that has already been made on this topic. We will introduce the datasets in Section 3. Section 4 will be allocated to the methodology. We will then dive into the analysis of our results in Section 5. Section 6 will be used to discuss the limitations of this study. Finally, we will draw a conclusion in Section 7.

2. Literature review

2.1 Investing in Wine

As we have mentioned above, a lot of research has been done in the past 45 years. The first research studying the performance of wine compared to more classical assets has been made in 1979 by Krasker. He concluded that returns on fine wine are lower than riskless assets, represented by bonds. Jaeger (1981) found the opposite results two years later. In 2001, Burton and Jacobse took into consideration the transaction cost and found that return on wine were higher than bonds but lowers than equities. The findings of Sanning and al (2008) were in the same direction. They concluded that wines offer higher-than-average risk-adjusted returns, and investment-grade wine assets have less exposure to market risk, which helps diversify portfolios. Fogarty (2010) also concluded on top of that, that finer wines have higher returns and lower volatility than poorer wine. We know that returns and diversification slightly differ from the region in which the wine is produced. (Kourtis et al., 2012). And to the best of our knowledge, no studies have been made with a focus on California.

Masset and Henderson (2010) have probably made the biggest work regarding investment in fine wine and their article is still used nowadays as the basis in a lot of new studies. They used different methods to test their hypothesis. It is a weighted average of observed prices of fine wine auction taking place at the Chicago Wine company from 1996 to 2007 that constituted their data set. Thanks to an Application of Vector Error Correction Model (VECM), a GARCH model, different Sharpe ratios comparison, analyzing the mean-variance efficient frontier and finally, thanks to a mean-variance-skewness-kurtosis analysis, they were able to conclude that wine returns were above Dow Jones Industrial Average.

Including wine in a portfolio offers several advantages: a higher Sharpe ratio, an increase in the skewness as well as in the kurtosis. (Masset & Henderson, 2010). They also provided a first analysis of the correlation between different categories of wine. They concluded that wine from different categories follow independent variation in the short term but end up following a similar trend in the long term. Finally, they have shown that in normal

circumstances, wine assets have a low correlation (-0.22 to 0.5) with traditional assets, but the correlation increases during financial crisis.

Aytaç and Mandou (2016) have made a comparable study than what we will do, but they focused only on French fine wines and gold. Their methodology was close to the one Masset and Henderson used six years earlier, including a return of observed prices to collect their data and a skewness-kurtosis analysis, a mean-variance efficient frontier and a mean-modified value at risk to analyze their data. They also studied the impact of gold in a portfolio, gold being an important source of investment for French people (Hoang, 2012). Their findings were close to Masset and Henderson (2010). Wine indeed, outperformed equities for the period they have studies. Also including French wine in a portfolio benefits the diversification of this later.

Those two articles, due to their completeness, will be the starting point of this study. First, the process for data collection needs to be chosen extremely carefully. Wine's benefits for diversity and return rely on the estimating technique used. For example, repeat sales approach overstates the return of wine and hybrid approach provides the most efficient estimates (Fogarty & Jones, 2011). And secondly the different estimation method they used can guide us on the right paths to take.

We will use a mean-variance portfolio optimization approach which is widely used approach in finance that helps investors construct portfolios with desirable risk-return characteristics (Markowitz, 1952). We will also build a mean-modified value-at-risk portfolio optimization in order to have an alternative approach to portfolio construction that combines the concepts of mean return and modified-value-at-risk (MVaR) (Favre & Galeano, 2002). In order to calculate the performance of our portfolio, we will use a Sharpe ratio (Sharpe, 1964) as well as a modified Sharpe ratio (Gregoriou & Gueyie, 2003).

The goal of using different methods is to have the most efficient estimates as explained by Fogarty and Jones (2011). Finally, to evaluate optimal weight to allocate depending on the alternative asset used and the investor profile, we will perform a Sharpe and Modified-Sharpe ratios maximization.

Something that also clearly needs to be considered is the overall cost of investing in wine is higher than for traditional financial assets, which have lower transaction costs and negligible storage fees and assurance necessity. Moreover, wine assets do not provide any dividends or coupons like we have with stocks and bonds. Furthermore, as presented by Kourtis et al (2012), wine is a “agricultural” good. The final results, quantity and quality, which impact on the price, vary based on different factors such as climate, production technologies or the expertise of the chateau, to name a few. On the other hand, investing in wine offers greater tax benefits than those traditional financial assets. (Masset & Henderson, 2010).

Based on this literature review we expect the same result as Aytaç and Mandou (2016). Their results were in line with the previous literature so we would be surprised if our findings differ significantly from the previous studies. But it will be interesting to compare the different impacts because the wine assets and the equities assets are not the same. They used only French assets; we will use only American assets. We see two directions in which the results could go. First, American wines have a strong and positive impact on a portfolio thanks to the growing reputation of their regions, especially California, on which our focus will be, and Nappa Valley region for example. The second is that, since the US stock market is already the strongest, wine does not have a significant impact, and an optimal portfolio would not have a substantial weight in wine.

2.2. Californian Wine

Californian wine has built itself a strong reputation in the global fine wine market over the past decades. The best proof for that is the Liv-ex California 50 index creation in August 2018. There are a few elements that can explain this growing reputation of Californian appellation.

First, California offers a lot of advantages from its climate and geographical position. The important number of microclimates present in the state allows vineyards to cultivate a wide range of grape varieties. Moreover, vineyards can enjoy the Mediterranean environment; warm, dry summers and mild, rainy winters, which is ideal for viticulture. Also, the Pacific Ocean's cooling effects help coastal areas maintain the proper balance of acidity and sugar in grapes, which is necessary for the development of fine wine. (Jones & Webb, 2010).

Secondly, California, land for innovation, has played a significant role in this development. Techniques such as canopy management, precision viticulture, and sustainable farming practices have significantly improved grape quality and yield (Robinson & Harding, 2015). Winemakers in California have also been pioneers in experimenting with new fermentation techniques and oak aging processes, contributing to the uniqueness and complexity of their wines (Morrison & Rabellotti, 2007).

Thirdly, marketing is also a key element of their reputation building. The Californian wine market used perfect branding and narrative to highlight the distinctive terroir and history of their region. Strategic partnerships and exports also have expanded the market reach, making California wines accessible to a global audience (Olsen et al, 2007). Additionally, the rise of wine tourism in regions like Napa Valley and Sonoma has enhanced consumer engagement and brand loyalty (Lockshin & Corsi, 2012). Those regions have become synonymous with high-quality wine and this image has been strengthened by critical praise from wine contests. Their consistent high ratings from wine publications and awards from international competitions have increased consumer confidence and demand for California wines (Charters & Pettigrew, 2007). For example, Californian wine outperformed French wine in 1976 at the blind tasting Judgment of Paris. This event was a complete surprise and played a crucial role in establishing California's reputation on the world stage (Taber, 2005). Fourthly, the success of California wines has also been influenced by consumer trends and economic factors. Spending on premium wines has increased due to the growth of the middle class and rising disposable income in different parts of the world. Furthermore, California wineries have enjoyed the rising trend of wine consumption among younger demographics, who are frequently willing and more open to discovering new wine areas (Bruwer et al., 2011).

Finally, sustainability has grown in importance as a selling point and Californian wineries have been at the forefront of implementing sustainable methods and thus, attracting customers who care about the environment. The marketability of California wines is increased by certifications such as the California Sustainable Winegrowing Alliance (CSWA) and certifications for organic or biodynamic production (McEwan & Bek, 2009).

To sum up, Californian wines success can be attributed to a combination of climatic advantages, innovative viticultural practices, historical milestones, strategic marketing, critical acclaim, economic trends, and a strong focus on sustainability. These factors collectively contribute to the robust and growing reputation, and global demand for wines from this region.

3. Data and descriptive Statistics.

This study focuses on a period of 10 years from January 2014 to January 2024. This has been conditioned by the availability of Californian wine indexes data. Indeed, CultX has the shortest data history related to American wines, starting in January 2014. Liv-ex indexes are very prestigious and hard to get. We have been able to collect; Liv-ex California 50 and Liv-ex 100, monthly, from January 2014 to January 2024; Liv-ex Investable, on a monthly basis, from January 2014 to May 2018; and Liv-ex 50, on a daily basis, from January 2014 to February 2023. This limitation will be discussed in Section 6. Stock and bonds are covered from January 2014 to January 2024.

3.1 Wine prices

Wine indices are divided into two categories. The first one is indexes focusing on the Californian market and the second category focuses on fine wines regardless of their place of production.

In this first category, we have the Liv-ex California 50 index, that has been published for the first time in August 2018, tracking the performance of the ten most recent vintages of five highly traded Californian wines: Screaming Eagle, Opus One, Dominus, Harlan Estate, and Ridge Monte Bello. The historical data has been manually collected thanks to plotdigitizer.com, based on a chart published on Liv-ex website. The second American wine index comes from CultX. This platform is known for buying, selling, collecting, and investing in fine wine. The data set is actually realized by Wine-Searcher, a web search engine focused on providing consumers the cost and availability of a specific wine, whiskey, spirit, or beer

anywhere in the world and getting connected to a company that sells the alcoholic beverage. The average wine price, which is used to build their index, is determined as follows: “A wine's average price is calculated from all available offers for a wine, with the top and bottom 20 percent removed. These average prices are updated daily, and exclude sales tax, which can vary considerably from country to country.” (Wine-searcher). CultX outsources this work rather than using their own trading information, to protect the integrity of the Cult Wines Indices. CultX keeps private the components of its index, which leads to another limitation of this study. This will be studied in Section 6. However, we know that this index focuses on USA fine wine. According to Winefolly more than 75% of the best USA Wines are from California. We will thus consider Cultx as a good index reflecting the performance of the Californian fine wine market, while keeping this assumption in mind for our conclusion.

To study the impact of Californian wines compared to global fine wines, we will work with three other indexes: Liv-ex 50, Liv-ex 100 and Liv-ex Investable. Liv-ex, for The London International Vintners Exchange is known worldwide for its wine marketplace which provides extensive data to build its indexes. The 50 wines in the Liv-ex Fine Wine 50 come from the last ten "physical" vintages (i.e., not "en primeur") of the Bordeaux region's first five growths: Margaux, Haut Brion, Lafite, Latour, and Mouton Rothschild. According to Reuters, the second index, Liv-ex Fine Wine 100, is the "leading benchmark for the fine wine industry." It is made of hundreds of wines. The majority are French wines, but we find also some Italian, 5 Californian and 1 Spanish. Last but not least, Liv-ex Fine Wine Investables features about 200 wines from 24 of the best Bordeaux chateaux that are considered the most "investable" wines. Based on Robert Parker's ranking, the component wines are selected and date back to 1982 vintages. Wines had to receive at least 95 points. But if the score is more than 90, the top eight Bordeaux "brands"—the first five growths included in the Liv-ex 50 ranking plus Ausone, Cheval Blanc, and Petrus—are included. It is important to note that those three indexes are heavily represented with French wines, and especially Bordeaux, due to their historical importance and market demand, even though the region itself is not a criterion to integrate those indexes.

All Liv-ex indices are constructed by the “mid-price” method. The mid-price is the mid-point between the current highest bid-price and the lowest offer-price on the Liv-ex trading

platform. This “mid-price” is then multiplied by the wine’s average production quantity. This ratio excludes wines that have more than 25 years from the vintage due to their low available volume. More information is available on the Liv-ex website. Once again, the data covers Liv-ex 100 from January 2014 to January 2024 on a monthly basis; Liv-ex 50 from January 2014 to January 2023 on a daily basis and Liv-ex Investables is covered from January 2014 to January 2018 on a monthly basis. This limitation will be addressed in Section 6.

All the Liv-ex indices have been collected from Bloomberg.

3.2 Stocks and bonds

To test different American portfolios, our method is inspired from the one developed by Canner et al. (1997). The assets that will be considered are bonds, blue chips (stock of companies having a high market valuation), mid-cap, small-cap, and international stock. The bond which will be considered as our risk-free asset is the US 10-years treasury bond. The reason why we choose the 10-years treasury bond over the 1 year one is because of the covid crisis impact on the yield during the pandemic. The 1-year bond has been much more impacted than the 10-years bond. We deem that this was not a normal economic environment and does not reflect the typical returns bonds usually offer.

The blue-chip is represented by one of the most famous indices in the world, S&P 500, known for tracking the 500 largest US stocks. For mid-cap and small cap stock, we will use respectively, the S&P MidCap 400 and S&P SmallCap 600. S&P indexes are market capitalization weighted. This means each component stock in the index is weighted according to its total market value. All S&P indexes have been collected from Yahoo Finance. Finally, the international stock will be represented by the MSCI World index, which has been collected from Investing.com.

Fig. 1 represents the dynamics of five different index investments. We can notice a strong correlation between the S&P 500 and the MSCI world. Which makes sense since 69% of the MCSI world index is composed of US stocks (MCSI Website). We can also see that Liv-ex California has an overall more important return than its counterpart, CultX, but the trend

seems the same. A deeper analysis is shown in Fig. 2. Another conclusion we can draw is Californian wines have a higher overall return than the global wines, represented by Liv-ex 100. The latter is also our lowest 10-year return represented on this chart. Finally, from this initial analysis, it appears that wine indices are either uncorrelated or negatively correlated with traditional stock investments. A deeper analysis will follow in this section.

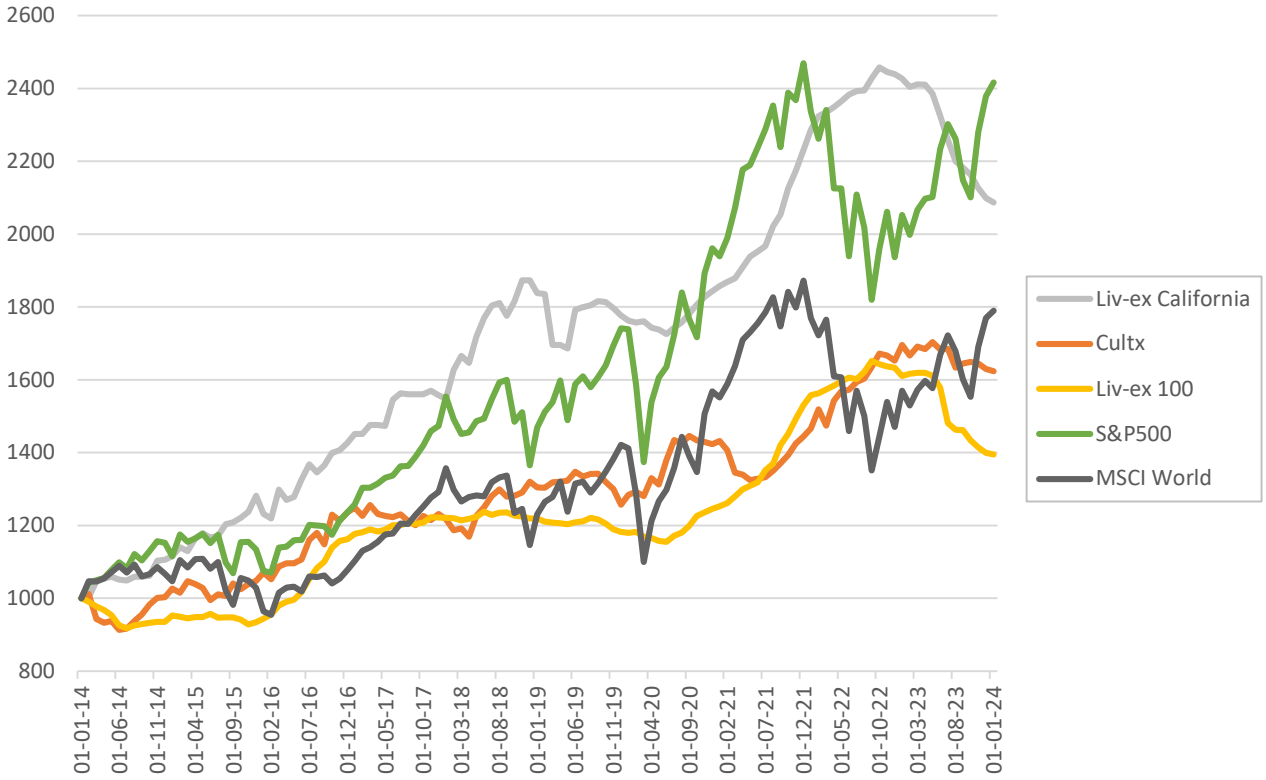

Fig. 1 Dynamic of wine, stocks, and bonds from January 2014 to January 2024 with a 1000$ starting capital.

As we can see in Fig.2, S&P 500 is the index with the highest volatility. This chart also confirms our analysis in Fig.1, indicating the lack of correlation or negative correlation between the wine indices and the US stocks and bonds. Moreover, we can observe a slight correlation between our two different wine indices, one representing the Californian market and one in the worldwide market. Table 1 provides the exact correlation figures, and Table 2 confirms this initial analysis by showing the descriptive statistics for each index.

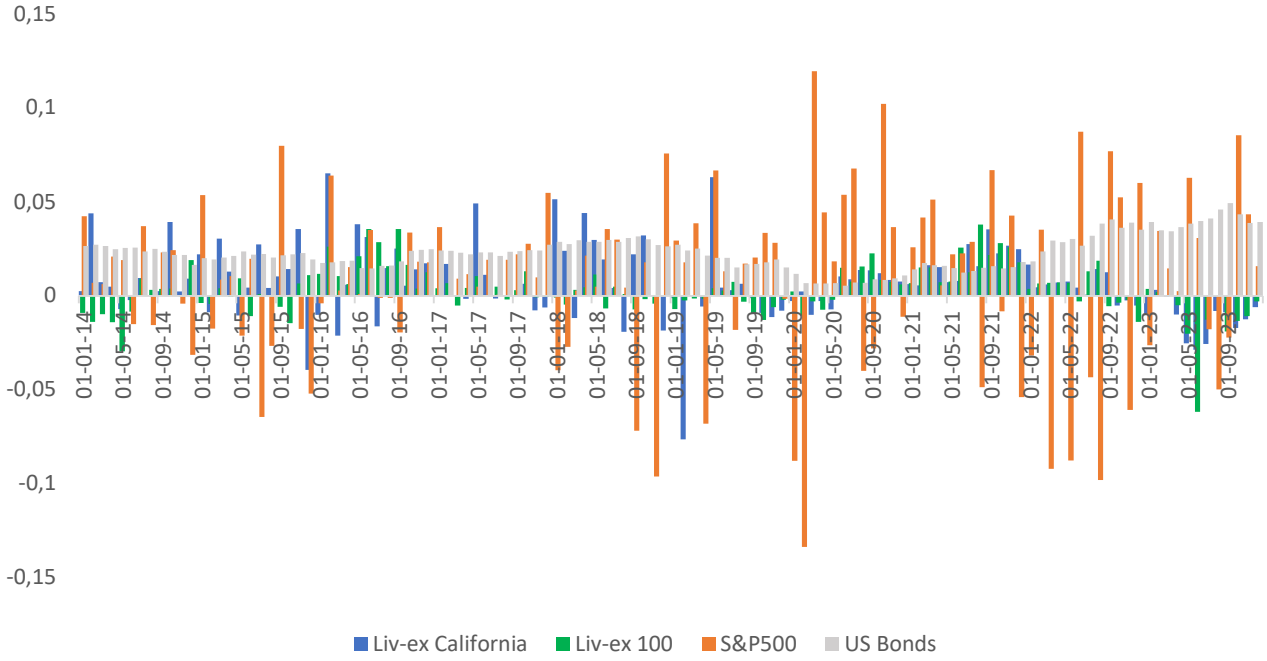

Fig. 2 Monthly returns of Californian and global wines, stocks and bonds. *Note: Only those 4 indexes have been kept due to visibility reasons.*

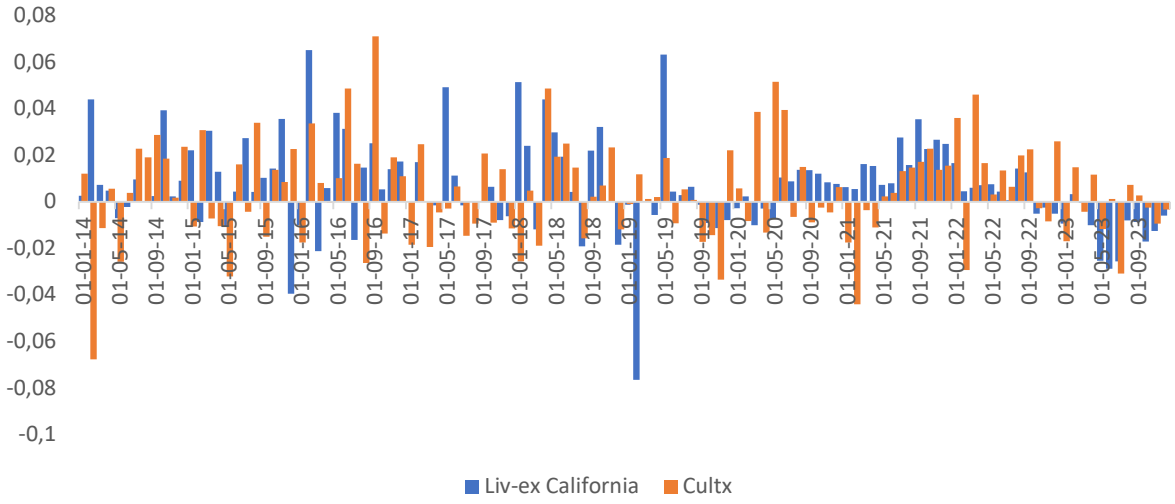

Fig. 3 Monthly returns of Californian wines indexes.

If we focus on our two different Californian wine indexes in Fig. 3, we can see their correlations. To our surprise, and as confirmed in Table 1, we expected a stronger correlation than what was found. The goal of retaining these two different but similar indices is to have a hybrid approach which provides us with the most efficient estimates as demonstrated by Fogarty and Jones (2011). Moreover, regarding the correlation between the different indices being studied, we are surprised to see the biggest negative correlations are between the bonds rate and the different wine indices. Those negative correlations are even more

pronounced than between stocks indices and bonds. Another interesting correlation to point-out is between the Liv-ex 100 and our 2 Californian indices, being significantly different from zero at 1% threshold. That proves that Californian fine wine does follow the same trends as the global market for fine wines, which is in line with the work of Masset and Henderson (2010).

Table 1:
Correlation between our different indices.

	S&P500	*S&P MidCap 400*	*S&P Small Cap*	*MSCI World*	*Monthly bonds*	*Liv-ex California*	*CultX*	*Liv-ex 100*
Traditional indices								
S&P500	1,00							
S&P MidCap 400	0,80***	1,00						
S&P Small Cap	0,75***	0,85***	1,00					
MSCI World	0,86***	0,80***	0,75***	1,00				
Monthly bonds	-0,06	-0,07	-0,07	-0,06	1,00			
Wine indices								
Liv-ex California	0,01	0,03	0,05	0,00	**-0,19****	1,00		
CultX	-0,05	-0,03	-0,03	-0,06	**-0,11**	0,15	1,00	
Liv-ex 100	-0,10	-0,05	-0,05	-0,10	**-0,40*****	**0,34*****	**0,26*****	1,00

Note: To goal of this table was to understand the correlation between our Californian indices and the other main assets. This is why Liv-ex 50 and Liv-ex Investables are not present in this table. Also, this matrix has been shrunk with a $\lambda = 0{,}125$. Is significantly different from 0 at 1% threshold***, at 5%** and at 10%*

Table 2 represents the principal descriptive statistics of our different indexes, based on log-returns for the period of time presented above in Section 3. Those figures confirm our initial analysis of Fig.1, but we have now included all our different indexes. Blue-chip index, represented by the S&P 500, has the strongest average return with 10.47%. In second position regarding the returns, we have Liv-ex Cal. with 7.87%. Which is higher than its counterpart, CultX with 5.23%. We can note the Californian wines indexes have a higher average return than the global ones but their volatility, represented by the Standard Deviation (SD), is also more important. One surprising result of the wine indexes is the low standard deviation of Liv-ex 50. Stock indexes offer higher returns but also higher risk since their standard deviation is greater. Results show all stock indexes have relatively the same results except S&P 500 as discussed above. Finally, bonds offer the lowest annual returns and one of the lowest variations. This asset is considered as a risk-free asset, so its standard

deviation represents variation of the yield in time, but the returns of a bond investment is known when purchasing the bond.

If we look at the skewness, which measures the asymmetry of the distribution of returns, so a normal distribution has a skew of zero, we see that all our stock indexes have a significantly negative skewness which indicates a distribution with a tail on the left side. On the opposite, our global wines indexes have positive skewness, except Liv-ex 100, that is negative. It is surprising to see that these three indexes do not have the same symmetry. Finally, an interesting result is that we fail to reject the hypothesis that Californian wine indices have skewness different from a normal distribution.
Also, all our selected indexes have a significant positive kurtosis, except for the bonds. That means our different indexes have a distribution of return leptokurtotic. That translates into a taller, sharper peak and fatter tails than the normal distribution. We can also observe that our three biggest kurtoses are from wine indexes. That means returns are more clustered towards the mean than what we can find with stocks and bonds, and its fatter tail means we can find more extreme values as well. Our skewness and kurtosis analyses are confirmed by our Jarque-Bera test that rejects the hypothesis, at a 95% confidence level that the returns from our different indices are not normally distributed, except for the bond.

From this first analysis, we can conclude that during the period January 2014 to January 2024, S&P 500 had the strongest return. Liv-ex California had the strongest returns compared to the other wine indexes. California wines indexes have a higher volatility than the global ones. However, it is returns from stocks that have the highest volatility compared to bond and wine indexes.

Table 2:
Descriptive statistics

Indexes	Observations	Average	SD	Skewness	Kurtosis	Jarque-Bera
Cal. Wine Indexes						
Liv-ex Cal.	121	**7,87%**	6,74%	-0,03	2.98***	44.85***
CultX	121	**5,23%**	7,16%	0,04	1,21***	7,36**
Global Wine Indexes						
Liv-ex 100	121	3,49%	4,58%	-0,56**	4,45***	106,48***
Liv-ex Investables	48	5,55%	4,17%	0,73**	1,87***	11,30***
Liv-ex 50	2733	3,53%	2,71%	0,25***	3,49***	1416,51***
Stock Indexes						
S&P500	121	**10,47%**	15,13%	-0,54**	0,83**	9,25***
S&P MidCap 400	121	7,58%	18,36%	-0,76***	2,70***	48,53***
S&P Small Cap	121	7,04%	**20,33%**	-0,50**	2,71***	41,90***
MSCI World	121	7,18%	14,98%	-0,68***	1,02**	14,52***
Bonds						
US Bond 10 years	121	2,30%	3,16%	0,40*	0,10	3,33

Notes: The values of average returns and standard deviation have been annualized. Jarque-Bera is a test for the normality distribution. *** It is not normal at 1% threshold, ** at 5% and *at 10%. The kurtosis is already compared to the kurtosis of a normal distribution. Returns are based on the Adjusted Close Price to include dividends and stock splits.

4. Methodology

To respond to our research question, “To what extent do fine wines contribute to the performance of a portfolio? Research focused on the Californian territory”, we will follow the same methodology used by Aytac and Mandou (2016), composed in 4 parts coming from different researchers. We will split our data’s time frame in 2, 50/50 for each index being studied. The reason behind this is to perform an out-sample analysis. The benefit of this analysis is to use the first data set to generate a model, and the second data set is used to test the model and evaluate its generalization to unseen data. This approach will give more realistic results to our studies. An important point to present is that all the correlation and covariance matrix presented in the paper have followed a shrinkage based on the Ledoit & Wolf method. By proceeding so, it offers a more robust estimates, stability in calculations and a better generalization and reduced risk of overfitting. (Ledoit & Wolf, 2004)

- First, we will study the mean-variance efficient frontier, as suggested by Markowitz (1952) in his classical theory. The data set will not be split in this section, the main objective is to build a first, easy but global, trend of the different indices. (See Section 4.1)
- Second, we will consider the mean-modified value-at-risk (M-MVar) portfolio optimization suggested by Favre and Galeano (2002). This step is to avoid the limits of the mean-variance approach on non-normal distribution sample, presented in Section 4.1. As in Section 4.1, the data set will not be split in 2. (See Section 4.2)
- Third, we will calculate the optimal weigh allocation of wine in American portfolio thanks to a Sharpe and M-Sharpe ratio maximization depending on investors profile and the improvement made on the portfolio. This section will be performed with the most recent half of each data set (See Section 4.3).
- Fourth, we will compare the performance of different portfolios depending on wine inclusion or not thanks to the Sharpe ratio (Sharpe, 1964) and modified Sharpe Ratio that puts more emphasis on downside risk than overall volatility (Gregoriou and Gueye, 2003). This section will be performed with the oldest half of each data set and compared with the results obtained in Section 4.3 (See Section 4.4).

4.1 Mean-Variance efficient frontiers with wine

We will initially use the following program to determine the maximum expected return of each portfolio, under constraints to not have a variance above a certain level, to afterward, be able to constitute mean-variance efficient frontiers:

$$Max\ E(R_p)$$

S.t $$V(R\mathrm{p}) \leq \sigma_0^2$$

Where

$$E(R_p) = \sum_{i=1}^{n} w_i E(R_i)$$

$$V(R\mathrm{p}) = \sum_{i,j=1}^{n} w_i w_j cov(i,j)$$

$$w_i \geq 0$$

$$\sum_{i=1}^{n} w_i = 1$$

Where R_p is the rate of return of portfolio P, w_i and w_j $(i, j = 1, \dots, n)$ the fraction of the capital invested in asset i and j of portfolio P, $V(R_p)$ the variance of the returns of portfolio P, $cov(ij)$ the covariance of returns between assets i and j $(i, j = 1, \dots, n)$ and σ_0^2 being the maximum variance allowed.

We establish efficient frontiers for the reference portfolio first, followed by portfolios diversified by wine assets, based on the concept explained below.

The S&P 500, S&P MidCap 400, S&P SmallCap 600, MSCI World, and the US 10 Years Treasury Bond constitute our initial and reference portfolio. The diversified portfolio will be composed of six assets. The five listed just above, composing our reference portfolio, and one wine index. Since we have five different fine wine indexes, we will build five diversified portfolios. The efficient borders with wine will be higher than those without, if diversification with it is profitable. In this case, the portfolios including wine will have a better rate of return at a given risk level compared to the initial portfolio, or it will have a lower risk for a given rate of returns.

4.2 Mean-Modified Value-at-Risk (M-MVaR) efficient frontiers with wine.

The method developed by Markowitz (1952) and used in Section 4.1 has some limitations. Indeed, using this method for non-normal distribution returns, the results provided can be misled. This method, M-MVaR, accounts for higher moments of the distribution such as skewness and kurtosis, also called the 3rd and 4th moment of the distribution. Indeed, a distribution skewed to the right should not have the same conclusion as a distribution skewed to the left. The same conclusion applies for a positive or negative kurtosis. We need to use a system the either penalizes or rewards those deviations from normality. Indeed, positive skewness and negative kurtosis should be rewarded against negative skewness and positive kurtosis. As we have seen in Table 1, most of our indexes have a 3rd and 4th moment significantly different from 0, and thus a non-normal distribution. For these reasons we choose to complete our study with the modified value-at-risk (MVaR) proposed by Favre and Galeano (2002) to complete the previous model presented in Section 4.1. The model is built as follow:

$$MVaR = W[\mu - \left\{z_c + \frac{1}{6}(z_c^2 - 1)S + \frac{1}{24}(z_c^3 - 3z_c)(K-3) - \frac{1}{36}(2z_c^3 - 5z_c)\,S^2\right\}\sigma]$$

Where MVaR is the modified value-at-risk, W the value of portfolio which is exposed to risk (we consider that it is 1 in our calculations), the average return, z_c the statistical value of the normal distribution law, at 5% z_c= −1.96, S the skewness, K the excess kurtosis compared to 3 (it is already compared to 3 in Tab1) and σ the standard deviation of returns.

Overall, value-at-risk quantifies the possible loss that may occur only with a specific probability. In our study, we will use the standard 5% threshold. This indicates that the potential loss that the MVaR measures has a 5% chance of being exceeded. This explains that the weighted total of the MVaRs of the individual assets that make up the portfolio is the MVaR of the portfolio. Stated differently, the weighted total of the individual assets that make up a portfolio represents its potential loss. The greater the MVaR, the greater the portfolio's possible loss which is why we look for the lowest MVaR.

We will first use the following program to estimate the least MVaR portfolio before drawing the Mean-MVaR efficient frontier curve:

$$Max\ E(R_p)$$

S.t.

$$MVaR(R_p) \leq MVaR(R_p)_0$$

With,

$$E(R_p) = \sum_{i=1}^{n} w_i E(R_i)$$

$$MVaR(P) = -R_p - \sigma_p - \left\{ z_\alpha + \frac{1}{6}(z_\alpha^2 - 1)S_p + \frac{1}{24}(z_\alpha^3 - 3z_\alpha)(K0_p - 3) - \frac{1}{36}(2z_\alpha^3 - 5z_\alpha)S_p^2 \right\}$$

Where,

$$S_p = \frac{\sum_{i=1}^{n} w_i^3 S_i \sigma_i^3}{\sigma_p^3}$$

$$K_p = \frac{\sum_{i=1}^{n} w_i^4 K_i \sigma_i^4}{\sigma_p^4}$$

$$w_i \geq 0$$

$$\sum_{i=1}^{n} w_i = 1$$

W being the percentage of the portfolio exposed to the risk, which we consider as 1. P is the average return, S its skewness, K the excess kurtosis compared to 3, σ its standard deviation and finally, z_α is the statistical value of the normal distribution which is 5% by convention so $z_c = -1.96$

By maximizing the expected return of each portfolio, under the constraint of not going higher than certain MVaR, more efficient portfolios on the curve can be discovered. We will establish efficient frontiers for the initial portfolio, that is our reference, as well as the portfolios diversified by wine, as previously mentioned in the subsection.

4.3 Optimal weights and efficiency improvements

To study statistical optimal weights of wine investments that should be invested in a portfolio, according to the risk profile of the investor (see Table 3), we will maximize the Sharpe and M-Sharpe ratio. The Sharpe ratio (Sharpe, 1964) is a measure of the excess return per unit of risk in an investment or portfolio. One of the criticisms this method received is that it treats the upside and downside volatility equally. In response to this argument, the Modified Sharpe Ratio was introduced by Favre and Galeano (2002). An alternative method that puts more emphasis on downside risk than the overall volatility. The unit of risk is not the standard deviation, like in the Sharpe Ratio, but it is the MVaR. For both, we look for the highest ratio, meaning we increase the return for the risk associated or we decrease the risk for the same rate of return.

We will study the optimal amount that should be included in a portfolio, according to the investor risk profile, and the index being used as the alternative asset. In addition to the optimal weight to allocate for each index, we will determine the improvement it creates compared to the reference portfolio composed only of traditional assets. To build the different optimized American portfolios according to their risk profiles, we will be inspired by the method proposed by Canner et al (1997) and used by Aytac et al (2016) stipulating that the composition of a portfolio is determined by the risk aversion of the investors. Those different risk aversions result in different portfolio allocation from the most risk-averse to the most risk-lover one: conservative, moderately conservative, balanced, moderately aggressive and aggressive investors (see Table 3). The most risk-averse investor will allocate 80% of his portfolio to bonds while the most risk-lover one will invest 100% of his capital in stocks.

In the first step of this method used to understand the efficiency of Californian fine wine in a portfolio, there is no maximization model to solve. The Sharpe-ratio results from the different investor risk profile is the consequences of the different allocations imposed. This will give us our reference portfolios for the 5 different risk investors profiles.

Table 3:
Asset allocation depending on investors' risk profiles (figures are in %)

	Conservative	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Bonds US 10 Years Treasury	80	60	40	20	0
Blue chips S&P500	20	20	30	40	40
Mid-Caps S&P MidCap400	0	10	10	15	20
Small Caps S&P Small Cap	0	10	10	15	20
International MSCI World	0	0	10	10	20

Once we have our reference portfolio, we will add fine wine assets as potential inputs to maximize the Sharpe and M-Sharpe Ratios, as presented below. To keep the different risk profile, we are adding weighting constraints as presented in Table 4, for an easier understanding. Wine assets weight is free of constraint for every portfolio, except the non-negativity constraint. For example, a balance investor could allocate as much weight as he wants to fine wine assets but regarding the rest of his resources; Mid-Caps, Small Caps and International must be the same weight, Blue chips must be three times bigger than Mid-caps, and Bonds must have four times more weight than Mid-Caps.

We will also solve a maximization with no constraints, except the non-negativity, to see how our results and portfolio composition varies if we have 0 investor risk profile constraint to meet.

Table 4:
Proportional allocation constraints for portfolios depending on investor profile.

	Conservative	Moderately Conservative	Balanced	Moderately Aggressive	Aggressive
Bonds US 10 Years Treasury	4X	6X	4X	2X	0
Blue chips S&P500	1X	2X	3X	4X	2X
Mid-Caps S&P MidCap400	0	1X	1X	1,5X	1X
Small Caps S&P Small Cap	0	1X	1X	1,5X	1X
International MSCI World	0	0	1X	1X	1X

First, the Sharpe Ratio maximization is built as follow:

$$Max\ S$$

Where,

$$S = \frac{E(R_p) - R_f}{\sigma_p}$$

$$E(R_p) = \sum_{i=1}^{n} w_i E(R_i)$$

$$R_f = \ the\ monthly\ \ average\ 10\ years\ treasury\ bond\ rate$$

$$\sigma_p = \sqrt{\sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j \sigma_{ij}}\ \ where\ \sigma_{ij}\ is\ the\ covariance\ between\ asset\ i\ and\ asset\ j$$

With

$$w_i \geq 0$$

$$\sum_{i=1}^{n} w_i = 1$$

Secondly, the M-Sharpe Ratio maximization is built as follow:

$$Max\ Sh_m$$

Where,

$$Sh_m = \frac{R_p - R_f}{MVaR}$$

$$w_i \geq 0$$

$$\sum_{i=1}^{n} w_i = 1$$

Where all the components have been presented above.

4.4 Sharpe and modified Sharpe performance measures

Following the different methods explained above we will challenge the results obtained in Section 4.3. To do so, we will examine if higher Sharpe and M-Sharpe ratio can be achieved with another percentage of wine investment than the one maximized in Section 4.3. Of course, if we use the same data, we will have the same result so this method will be computed with the oldest half of our data sets. The goal is to create an out-sample analysis, with the benefits that have been presented above in the methodology. As demonstrated above, we will use the Sharpe ratio (Sharpe, 1964) and the modified Sharpe ratio (Favre and Galeano, 2002). The calculation of these two performance ratios is as follows:

The Sharpe Ratio (Sh) is constructed as follow:

$$Sh = \frac{R_p - R_f}{\sigma_p}$$

With R_p being the portfolio return, R_f the return of a risk-free asset and σ_p the standard deviation of our portfolio returns and detailed in Section 4.4.

The modified Sharpe Ratio (Sh_m) is constructed as follow:

$$Sh_m = \frac{R_p - R_f}{MVaR_p}$$

With R_p being the portfolio return, R_f the return of a risk-free asset, σ_p the standard deviation of our portfolio returns and MVaR the Modified Value-at-Risk presented in Section 4.2.

In total, we will build 330 different portfolios. Indeed, for each of those five risk profiles, we will include 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% of wine. Of course, we will need to exclude the same total percentage from the different assets composing the initial portfolio. Since we will include five different wine indexes, and keep one initial portfolio without any wine assets, the total goes to 330. $(5\ x\ 6\ x\ 11 = 330)$. Sharpe and M-Sharpe ratio results are not solved by a maximization problem, but rather as a result of the different inputs “forcibly placed” in each portfolio.

5. Result and discussion

5.1 Mean-variance efficient frontiers

The results of the mean-variance efficient frontiers study can be observed in Fig. 4. The results show that portfolios with fine wine assets available always reach a higher frontier than the reference portfolio, composed only of stocks and bonds, no matter the type of wine asset (except on the last point where the two frontiers converge). This means that for the same degree of risk, we can reach a higher rate of return, or for the same rate of return, we can lower the risk associated with that return. One analysis that can be noted is that this frontier improvement is more important with a lower level of risk, calculated with the standard deviation. That means if investors are more risk-adverse, and want to keep a low level of risk, including wine assets is a good choice. On the other hand, if investors are willing to take more risk. The difference between portfolios with and without wine assets decreases as the standard deviation increases. This can be explained due to the limited returns of wine assets which forces investors to focus more on stocks, specifically the S&P 500, that has the highest average rate of return as presented in Table 1, if they want to reach a higher expected return. Finally, if we compare portfolio with Californian wine assets versus global wine assets, we can see that the Californian one has a higher frontier, meaning that incorporating the latter offers a better improvement than incorporating global fine wines assets to a referent portfolio.

Regarding now the value of the shrinkage intensity (λ), it is for every matrix evaluated between 0.1 and 0.15. This value close to 0 means the shrinkage is minimal, and the covariance matrix is largely determined by the empirical data. We can proceed like this thanks to a large dataset with many observations compared to the number of variables. Also, the data is stable and with low-noise.

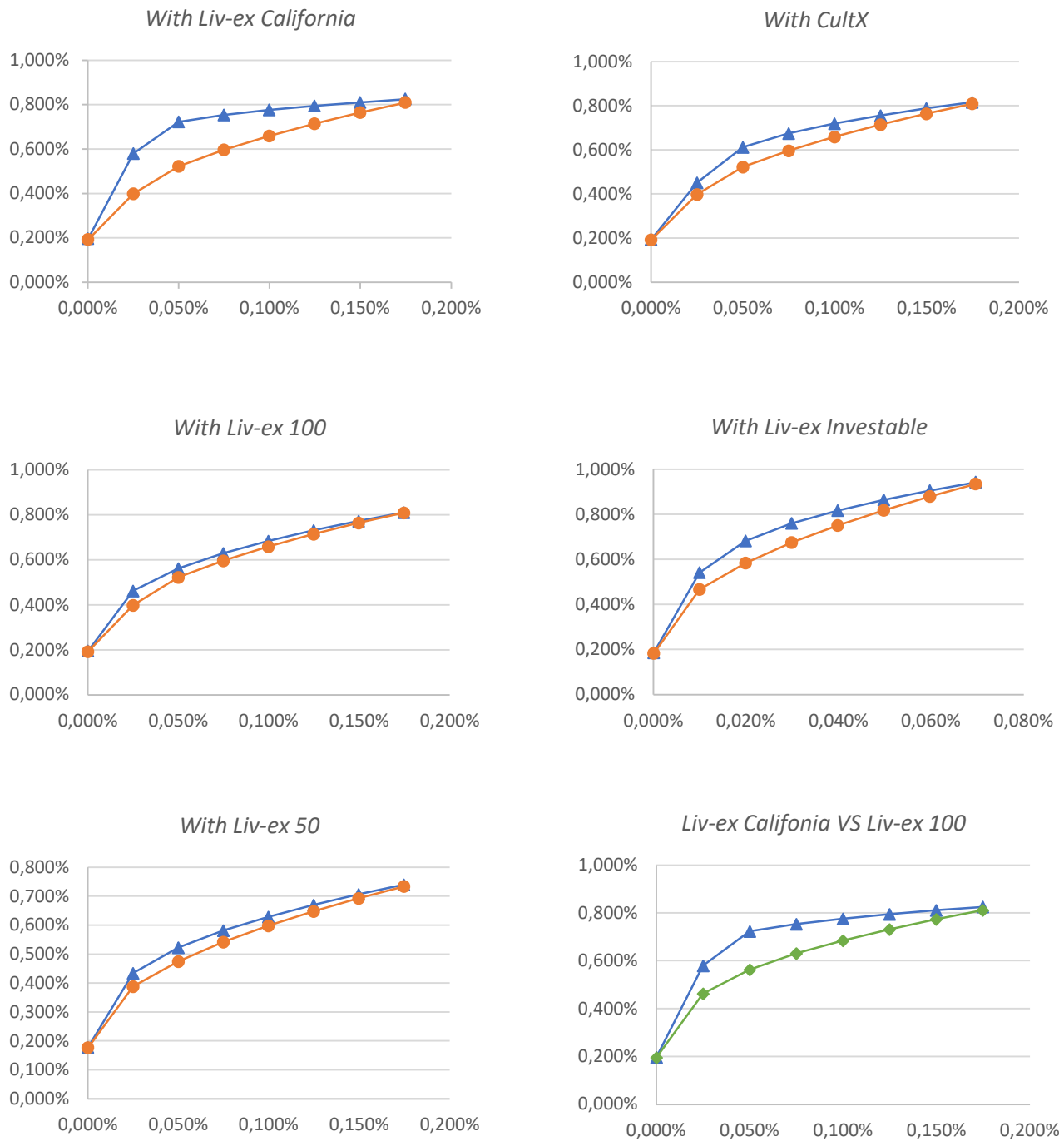

Fig. 4: Mean-variance efficient frontier of portfolio with and without wine. *Notes: The curves with circle points are the reference portfolios and curves with triangle points are with the alternative asset. In Liv-ex California VS Liv-ex 100, the curve with triangle points represents the portfolio with Liv-ex California asset and the curve with rhombus points represents the portfolio with Liv-ex 100 asset. The x axis represents the monthly standard deviation, and the axis y represents the optimized monthly return for the risk x.*

5.2 Mean-Modified Value-at-Risk (M-MVaR) efficient frontiers with wine

Fig. 5, shows the different results of our M-MVaR-efficient frontiers with wine and the comparison we have between portfolios with or without wine assets availability. This new type of chart considers the third and fourth moment of distribution and the results are in line with what is observed in Section 5.1. Indeed, it confirms that for investors that are not willing to reach a higher risk level, including wine assets in their portfolio allows them to increase their expected returns while keeping the same level of risk. Oppositely as in Section 5.3, higher return can be achieved thanks to wine assets incorporation, mainly with the Californian ones. On the other hand, it is not always the case with global fine wine assets. This improvement is due to the third of fourth moment of distribution that are taken into account in the M-VaR analysis and that is positive from an investment point of view. Another point this study confirms is that a portfolio including Californian wines assets offers a better efficient frontier than a portfolio including global fine wine assets.

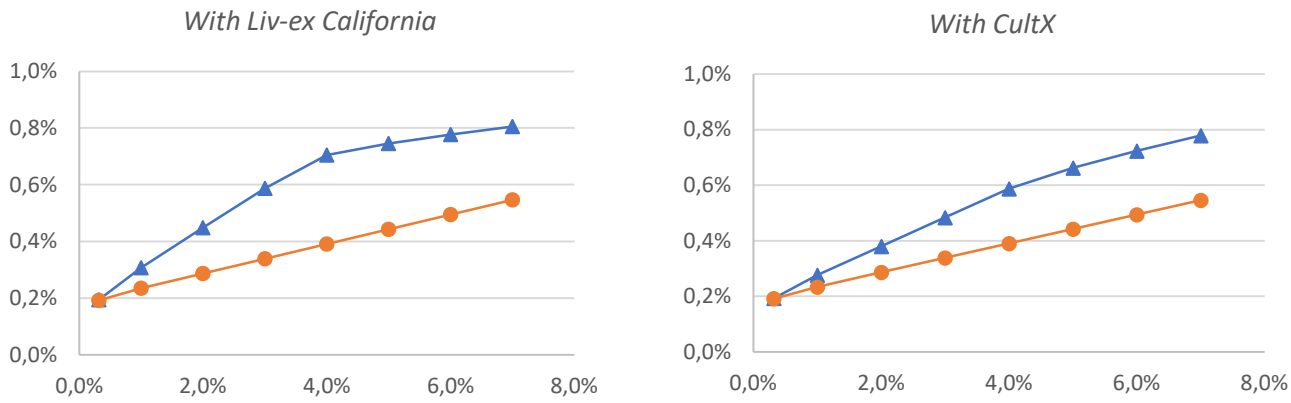

Fig. 5: *2 Mean-Modified Value-at-Risk efficient frontiers of portfolio with and without wine. Notes: The curves with circle points are the reference portfolios and curves with triangle points are with the alternative asset. In Liv-ex California VS Liv-ex 100, the curve with triangle points represents the portfolio with Liv-ex California asset and the curve with rhombus points represents the portfolio with Liv-ex 100 asset. The x axis represents the modified value-at-risk, and the axis y represents the optimized monthly return for the risk x.*

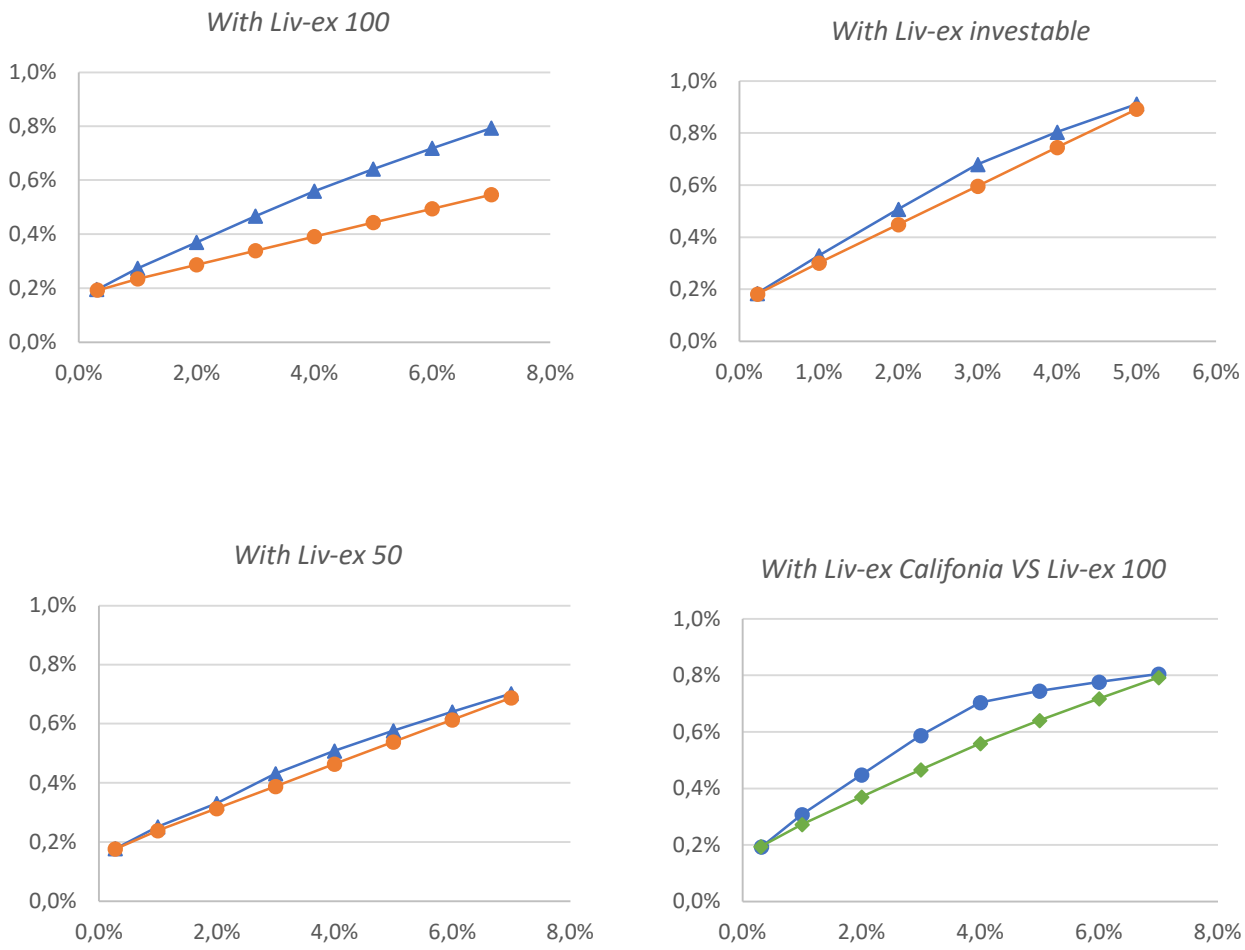

Fig5: (Continued)

5.3. Optimal weights and efficiency improvements of wine in American portfolios

Table 5 shows the different weights that should be included in a portfolio to maximize the Sharpe Ratio and the Modified Sharpe Ratio depending on the risk profile of the investor and the improvement that has been made regarding those two ratios compared to a traditional portfolio. An extra maximization has been made with no constraint, only the maximization objective. The results obtained are in line with the results discussed in our two previous sections, proving that adding fine wine assets, Californian included, is necessary to maximize the Sharpe and M-Sharpe ratio.

First focusing on the Sharpe Ratio, we see that to maximize this ratio, including fine wine, no matter which one (at least from the five indices we have studied) is mandatory. Depending on the investor profile, weights can vary from 4% to 74%. Specifically on Californian fine wine, more weight is allocated to the CultX index than to Liv-ex California. Another interesting conclusion is that the more aggressive the investor, the more fine wine assets should be included in the portfolio. Additionally, we can see that when profile-risk constraints are removed, we obtain a significantly lower weight of assets allocated to fine wine, ranging from only 4% to 13% depending on the index studied. However, except for the Liv-ex Investables, the results show that fine wine assets are indeed included to reach the highest ratios, but those ratios do not skyrocket compared to our reference portfolio, without any fine wine assets. Even more, they stay similar and do not have a significant difference. Fig.6 shows us the optimal weight allocation needed to reach those maximized ratios (without any constraints), depending on the new fine wine asset now available. Looking at the Sharpe Ratio, we can conclude that including fine wine assets, whether Californian or global, is needed to reach the highest ratios but the improvement of efficiency is not significant. The full portfolio's allocation can be found in the annexes.

Secondly, analyzing the M-Sharpe ratio results, the first look gives the approximately same results as with the Sharpe Ratio analysis, with optimal weight ranging from 3% and 72% depending on the index involved and the risk profile. However, the big surprise here comes from the fully optimized profile, without any risk-profile related constraints. Results obtained with the M-Sharpe ratio maximization are much higher than with the Sharpe Ratio maximization. This can be explained by the fact Sharpe Ratio focuses on optimizing returns in relation to total risk, taking into account all volatility equally. Given its lower predicted return when compared to high-performing assets like stocks, it recommends a smaller allocation to fine wine. On the other hand, the M-Sharpe Ratio takes skewness and kurtosis in returns into consideration and stresses downside risk. Under this metric, fine wine looks more favorable and justifies a bigger investment due to its potential for positive skewness and lower downside risk, for the period studied. This can be easily observed in Fig. 7, where the different charts also show the optimal weight allocation needed to reach those maximized ratios, depending on the new fine wine asset now available. We see that those percentages are much heavier than in Fig. 6, where the Sharpe ratio was maximized.

It is also important to keep in mind that the shorter time frame for Liv-ex Investables and Liv-ex 50 data have led to these results. Indeed, results obtained for those 2 indices are the highest ones regarding optimal weight to allocate. Since, the period studied here is only 4.5 years for Liv-ex 50 and even lower, 2 years for Liv-ex Investables, this shorter timeframe can explain those extreme values. Limitations will be discussed in Section 6.

To conclude this section, we can affirm that, based on both Sharpe ratio and M-Sharpe ratio maximization methods, fine wine assets, including Californian fine wine, needs to be incorporated into a portfolio to reach the highest ratios but the efficiency, characterized by the 2 ratios, does not improve significantly.

Table 5:

Optimal allocation to fine wine assets and its impact on Sharpe and M-Sharpe ratios, depending on the investor's risk profile and the fine wine index studied, compared to a traditional portfolio.

	Allocation	Sharpe	Allocation	M-Sharpe
Traditional Portfolio*				
Conservative	0%	1,18	0%	1,09
Moderately Conservative	0%	1,13	0%	1,07
Balanced	0%	1,14	0%	1,07
Moderately Aggressive	0%	1,14	0%	1,07
Aggressive	0%	1,13	0%	1,07
Fully Optimized	0%	1,18	0%	1,10
Californian Wine				
Liv-ex California				
Conservative	5%	+0,00	3%	+0,00
Moderately Conservative	11%	+0,00	7%	+0,00
Balanced	14%	+0,00	8%	+0,01
Moderately Aggressive	18%	+0,00	10%	+0,00
Aggressive	22%	+0,00	13%	+0,00
Fully Optimized	4%	+0,00	8%	+0,01
Cult X				
Conservative	19%	0,03	20%	0,01
Moderately Conservative	40%	0,03	40%	0,01
Balanced	47%	0,03	46%	0,02
Moderately Aggressive	55%	0,03	54%	0,02
Aggressive	62%	0,03	60%	0,02
Fully Optimized	13%	0,03	52%	0,01

	Allocation	Sharpe	Allocation	M-Sharpe
Global Wine				
Liv-ex 100				
Conservative	17%	+0,01	14%	+0,00
Moderately Conservative	33%	+0,00	28%	+0,00
Balanced	40%	+0,01	34%	+0,01
Moderately Aggressive	47%	+0,00	41%	+0,01
Aggressive	54%	+0,01	47%	+0,00
Fully Optimized	8%	+0,01	40%	+0,00
Liv-ex Investables				
Conservative	35%	+0,28	39%	+0,08
Moderately Conservative	52%	+0,25	53%	+0,07
Balanced	60%	+0,25	60%	+0,07
Moderately Aggressive	67%	+0,26	66%	+0,07
Aggressive	72%	+0,25	71%	+0,07
Fully Optimized	5%	+0,30	70%	+0,06
Liv-ex 50				
Conservative	28%	+0,01	27%	+0,01
Moderately Conservative	54%	+0,01	52%	+0,01
Balanced	61%	+0,02	59%	+0,01
Moderately Aggressive	68%	+0,02	66%	+0,01
Aggressive	74%	+0,02	72%	+0,01
Fully Optimized	12%	+0,01	62%	+0,00

** This portfolio has been built with data coming from January 2019 to January 2024. Therefore, it can only be compared with Liv-ex California, Cult X and Liv-ex 100. Liv-ex Investables and Liv-ex 50 have different results to be compared with but are not presented here to avoid excessive information.* Is significantly different from 0 at 1% threshold***, at 5%** and at 10%*.

Fig. 6: *Portfolio allocation to maximize the Sharpe ratio. The first portfolio is our reference, while the 5 others each have an additional fine wine asset available.*

Fig. 7: *Portfolio allocation to maximize the M-Sharpe ratio. The first portfolio is our reference, while the 5 others each have an additional fine wine asset available*

5.4 Performance of portfolios with and without wine (Sharpe and M-Sharpe Ratio)

Table 6 shows how the Sharpe ratio and Modified Sharpe ratio vary for our portfolios including different weights of wine assets and their performance compared to our reference portfolios, as presented in table 3. The comparison here is to see if we would have the same results as in Section 5.3.

First, if we look at the Sharpe ratios, we can see that including wine assets offers a better efficiency for 219 portfolios out of 220 created (if we exclude the Liv-ex Investable ones from this analysis), proving that including wine assets improves the performance of the portfolio. Depending on the investor profile and the type of wine asset included, the Sharpe ratio indicates that between 30% and 90% of the portfolio weight could be allocated to these alternative assets. Moreover, those improvements are much greater than the improvements discovered in Table 5. Also, California wines offer better efficiency than global wine assets. Indeed, the Sharpe ratio of portfolios including Californian wine assets can reach a much higher ratio compared to the reference portfolio and the portfolios including global fine wines. Now, analyzing the comparison to what we previously had, we see that those new results are always higher than what we obtained in Section 5.4 (Still excluding Liv-ex Investables). This means the 5 most recent years have been less attractive compared to traditional assets than the 5 years before that. Moreover, we have determined that the difference between our 2 results is, most of the time, significantly different. This could be sign of a poor first model generalization or a significant difference in the data distribution from our 2 different samples themselves. But that is not only bad news! Our model may not be complex enough, or the data differs too much overtime but there is still one thing that matches both analyses. It is the need to incorporate fine wine assets to improve the efficiency of a portfolio. Indeed, both our models suggest that investors should allocate some part of their investment to fine wine assets. The weight to allocate does vary depending on the model but the main action to take is the same, investing in fine wine.

Secondly, the Modified Sharpe ratio study confirms our first findings. Out of the 220 portfolios, 114 of them are improved if fine wine assets are incorporated (Still excluding Liv-ex Investables) and also greater than we what studied and presented in table 5. However, the

improvements created including wine assets, compared to our reference portfolio, are less pronounced than in the Sharpe ratio study. As with the Sharpe Ratio study, we observe that the new outcomes consistently outperform the ones we got in Section 5.4 (still ignoring Liv-ex Investables). This indicates that, in comparison to traditional assets, the last five years have been less appealing than the five years prior. However, one factor is consistent across all analyses; in order to increase a portfolio's efficiency, fine wine assets must be included. The discussion regarding the difference between the results from our two models presented above can be extended to this conclusion.

Finally, the reason we exclude Liv-ex Investables in our analysis is the extreme value obtained for this component, especially in this section, which may be due to the shorter time frame of the data studied, from January 2014 to January 2016 for Section 5.5 and from January 2016 to January 2018 for Section 5.4. We have judged those values too extreme compared to our other findings and the reduced timeframe gives us a justification to not involve them in our analysis of this study.

Table 6:
Performance difference between the reference portfolio (composed of classic assets only) and portfolio including wine assets, based on Sharpe and M-Sharpe ratios.

		5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		Sharpe	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**	**Sharpe**
Liv-ex California	Conservative***	5,0%	10,1%	19,8%	26,9%	31,1%	32,9%	**33,5%**	33,4%	33,0%	32,5%	32,0%
	Moderately Conservative***	2,4%	4,9%	10,6%	16,7%	22,7%	27,9%	31,7%	33,8%	**34,5%**	34,4%	33,7%
	Balanced***	1,7%	3,5%	7,6%	12,4%	17,8%	23,5%	28,6%	32,4%	34,5%	**34,8%**	34,0%
	Moderately aggressive***	1,2%	2,6%	5,7%	9,5%	14,0%	19,3%	24,9%	30,0%	33,5%	**34,8%**	34,0%
	Aggressive***	1,0%	2,1%	4,6%	7,7%	11,6%	16,3%	21,9%	27,8%	32,7%	**35,1%**	34,5%
CultX	Conservative***	1,7%	3,2%	5,7%	**6,7%**	6,4%	5,7%	4,7%	3,8%	3,1%	2,4%	1,8%
	Moderately Conservative***	0,8%	1,6%	3,4%	5,1%	6,4%	**7,1%**	7,1%	6,5%	5,6%	4,6%	3,6%
	Balanced***	0,6%	1,2%	2,5%	3,9%	5,4%	6,6%	**7,3%**	7,2%	6,4%	5,2%	3,9%
	Moderately aggressive***	0,4%	0,9%	1,9%	3,1%	4,4%	5,7%	6,8%	**7,3%**	6,8%	5,5%	3,8%
	Aggressive***	0,3%	0,7%	1,5%	2,5%	3,7%	5,0%	6,3%	7,3%	**7,4%**	6,3%	4,4%
Liv-ex 100	Conservative***	1,0%	1,9%	3,8%	5,0%	**5,4%**	4,9%	3,8%	2,6%	1,4%	0,3%	(0,6%)
	Moderately Conservative***	0,4%	0,9%	1,9%	3,1%	4,2%	5,1%	**5,5%**	5,2%	4,1%	2,7%	1,1%
	Balanced***	0,3%	0,6%	1,4%	2,3%	3,3%	4,4%	5,3%	**5,7%**	5,1%	3,5%	1,4%
	Moderately aggressive***	0,2%	0,5%	1,0%	1,7%	2,6%	3,5%	4,6%	**5,4%**	**5,4%**	4,0%	1,4%
	Aggressive***	0,2%	0,4%	0,8%	1,4%	2,1%	3,0%	4,0%	5,1%	**5,8%**	4,8%	1,9%
Liv-ex Investables	Conservative***	**(1,7%)**	(3,6%)	(7,8%)	(11,7%)	(14,7%)	(16,9%)	(18,3%)	(19,2%)	(19,9%)	(20,3%)	(20,7%)
	Moderately Conservative***	**(0,8%)**	(1,7%)	(3,7%)	(5,9%)	(8,2%)	(10,2%)	(11,8%)	(12,9%)	(13,5%)	(13,8%)	(13,8%)
	Balanced***	**(0,6%)**	(1,2%)	(2,6%)	(4,3%)	(6,3%)	(8,3%)	(10,3%)	(11,8%)	(12,8%)	(13,3%)	(13,3%)
	Moderately aggressive***	**(0,4%)**	(0,9%)	(2,0%)	(3,3%)	(4,9%)	(6,8%)	(8,9%)	(10,9%)	(12,5%)	(13,3%)	(13,5%)
	Aggressive***	**(0,3%)**	(0,7%)	(1,6%)	(2,6%)	(4,0%)	(5,6%)	(7,4%)	(9,4%)	(11,1%)	(12,0%)	(11,9%)
Liv-ex 50	Conservative***	0,9%	1,8%	3,3%	4,4%	**4,8%**	4,4%	3,6%	2,4%	1,2%	0,1%	(1,0%)
	Moderately Conservative	0,4%	0,9%	1,8%	2,8%	3,7%	4,4%	**4,7%**	4,4%	3,4%	1,8%	(0,0%)
	Balanced	0,3%	0,6%	1,3%	2,1%	3,0%	3,9%	4,6%	**4,9%**	4,4%	2,8%	0,4%
	Moderately aggressive**	0,2%	0,5%	1,0%	1,6%	2,4%	3,2%	4,1%	**4,7%**	4,7%	3,3%	0,3%
	Aggressive	0,2%	0,4%	0,8%	1,3%	2,0%	2,7%	3,6%	4,5%	**5,0%**	4,1%	0,8%

		5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe	M-Sharpe
Liv-ex California	Conservative***	2,3%	4,5%	8,4%	11,2%	12,9%	13,8%	14,2%	14,3%	**14,3%**	14,2%	14,1%
	Moderately Conservative***	1,2%	2,4%	5,0%	7,7%	10,1%	12,1%	13,6%	14,4%	14,8%	**14,8%**	14,7%
	Balanced***	0,8%	1,7%	3,7%	5,9%	8,3%	10,5%	12,5%	14,0%	14,7%	**14,9%**	14,7%
	Moderately aggressive***	0,6%	1,3%	2,9%	4,6%	6,7%	8,9%	11,1%	13,1%	14,4%	**14,9%**	14,6%
	Aggressive***	0,5%	1,1%	2,3%	3,9%	5,7%	7,7%	10,1%	12,3%	14,2%	**15,1%**	14,9%
CultX	Conservative***	0,7%	1,4%	2,5%	3,0%	**3,0%**	2,8%	2,5%	2,1%	1,8%	1,6%	1,3%
	Moderately Conservative***	0,4%	0,8%	1,6%	2,4%	3,0%	3,3%	**3,3%**	3,1%	2,7%	2,3%	1,9%
	Balanced***	0,3%	0,6%	1,2%	1,9%	2,6%	3,1%	**3,4%**	3,4%	3,1%	2,5%	1,9%
	Moderately aggressive***	0,2%	0,4%	0,9%	1,5%	2,1%	2,7%	3,2%	**3,4%**	3,2%	2,6%	1,8%
	Aggressive***	0,2%	0,4%	0,8%	1,3%	1,8%	2,5%	3,1%	3,5%	**3,5%**	3,0%	2,1%
Liv-ex 100	Conservative***	1,2%	1,6%	2,3%	2,8%	**2,8%**	2,6%	2,0%	1,5%	0,9%	0,4%	(0,1%)
	Moderately Conservative***	0,2%	0,4%	0,9%	1,4%	1,9%	2,2%	**2,4%**	2,2%	1,8%	1,1%	0,4%
	Balanced***	0,3%	0,4%	0,8%	1,2%	1,6%	2,1%	2,5%	**2,6%**	2,2%	1,5%	0,5%
	Moderately aggressive***	0,2%	0,3%	0,6%	0,9%	1,3%	1,7%	2,2%	**2,5%**	2,4%	1,7%	0,4%
	Aggressive***	0,1%	0,2%	0,4%	0,7%	1,0%	1,4%	1,9%	2,3%	**2,5%**	2,0%	0,7%
Liv-ex Investables	Conservative***	**(0,8%)**	(1,8%)	(3,8%)	(5,8%)	(7,6%)	(8,9%)	(9,9%)	(10,6%)	(11,1%)	(11,5%)	(11,8%)
	Moderately Conservative***	**(0,5%)**	(1,0%)	(2,1%)	(3,3%)	(4,6%)	(5,8%)	(6,8%)	(7,6%)	(8,0%)	(8,3%)	(8,4%)
	Balanced***	**(0,3%)**	(0,7%)	(1,5%)	(2,5%)	(3,6%)	(4,8%)	(6,0%)	(7,0%)	(7,6%)	(8,0%)	(8,1%)
	Moderately aggressive***	**(0,2%)**	(0,5%)	(1,2%)	(1,9%)	(2,9%)	(4,0%)	(5,2%)	(6,4%)	(7,4%)	(8,0%)	(8,2%)
	Aggressive***	**(0,2%)**	(0,4%)	(0,9%)	(1,6%)	(2,3%)	(3,3%)	(4,4%)	(5,6%)	(6,6%)	(7,2%)	(7,2%)
Liv-ex 50	Conservative***	0,4%	0,7%	1,4%	1,8%	**2,0%**	1,9%	1,6%	1,1%	0,7%	0,2%	(0,2%)
	Moderately Conservative	0,2%	0,4%	0,8%	1,2%	1,6%	1,8%	**1,9%**	1,8%	1,3%	0,6%	(0,2%)
	Balanced**	0,1%	0,3%	0,6%	0,9%	1,3%	1,6%	1,9%	**2,0%**	1,7%	1,0%	(0,1%)
	Moderately aggressive***	0,1%	0,2%	0,4%	0,7%	1,0%	1,4%	1,7%	1,9%	**1,9%**	1,2%	(0,2%)
	Aggressive	0,1%	0,2%	0,4%	0,6%	0,9%	1,2%	1,6%	1,9%	**2,0%**	1,5%	(0,0%)

Note: Underlined numbers are our optimized value obtained in Section 5.4. Bold values are the maximum improvement made compared to our reference portfolio. The difference between our 2 results is significantly different at 1% threshold***, at 5%** and at 10%*

6. Limitation

The different results presented in the above sections have been made with some assumptions and some elements have been voluntarily omitted, which leaves a door open for further studies.

One assumption that has been made is that our expected future returns are based on past returns. This time series method is one way to forecast future returns, but it is important to note, it is not because something happened in the past that it will happen again in the future. Also, as we have seen in Section 5.3 and 5.4, the results of Liv-ex Investables are extreme compared to the four other indexes we have studied. The time frame of Liv-ex Investables is different. We only have four years of data regarding this index, and we can assume it impacts the Sharpe ratio and Modified Sharpe ratio. The data we are working with did not go through the covid crisis, which can explain this result to turn out to be an extreme value in comparison with other results. Another assumption that has been made is that CultX is focused only on Californian wine, which it is not. As explained in Section 3.1, taking the assumption that this index is mainly influenced by Californian wine, makes sense. However, this opens a door for future studies on the differences between Californian wines and the performance of the rest of the US wines performance. Furthermore, we do not know by which fine wines the CultX index is composed. Our results suggest that investors should allocate resources to Californian fine wine, but if we look only at the CultX index, we do not know which wines to invest in.

Looking at the omitted elements, we can name the purchasing cost and difficulty of investing in fine wine. To the best of our knowledge, there are no ETFs dedicated solely to wine, and even less for Californian wine. The indexes we have studied could be considered as ETFs to understand their meaning; they incorporate different fine wines, but it is impossible to invest in those indexes. They only track the general trend. Investors, unless they have enormous resources, cannot buy every asset of the index. Investors thus need to choose some wines from this index, which increases the risk. They could reach on a higher return, but it could also turn out to be a loss. Additionally, the fee for purchasing a bottle at an auction is higher

than purchasing a stock through your regular bank and has not been taken into account in this study. Moreover, storing a bottle costs more than holding a stock. Insurance or even maintaining a wine cellar to preserve quality is also more demanding than managing traditional assets. We cannot forget that if we break the bottle, the whole investment is lost. Finally, the liquidity of the wine market is lower than traditional investment options, which can lead investors to face challenges when they want to resell their assets. (Masset et al., 2021). To sum up, all those factors that were not considered into our analysis reduce the benefits of investing in wine, as we have demonstrated in this thesis. Its impact can be studied in complement study to this thesis.

7. Conclusion

This section concludes this thesis and summarizes the five different methods used to draw our conclusions.

First, based on the Mean-Variance efficient frontier and the Mean-Modified Value-at-Risk efficient frontiers, presented respectively in sections 5.1 and 5.2, we have demonstrated that including fine wine, whether global or Californian, improves the efficient frontier, particularly for lower levels of risk, based on the Mean-Variance, but Californian fine wine also offers higher return, compared to the risk, to a portfolio if included. We were also able to determine that a portfolio including Californian wines offers a better frontier than a portfolio composed of global wines. As presented in Table 2, wines assets have on average a lower return than stocks. However, based on this analysis, we can conclude that for the period studied (January 2014 – January 2024), Californian wine assets outperformed global ones. Moreover, the S&P 500 is the index offering the higher expected return.

Table 5 in Section 5.3 showed us the optimal weight method that once again confirms our previous analysis. Based on Sharpe ratio maximization, the results suggest that an investor should always include fine wine assets into his portfolio in order to maximize its Sharpe Ratio. Depending on their investing profile and the index selected, they should allocate between 4% and 62% to Californian fine wine assets. If all risk-profile constraints are

removed, between 4% and 13% should be allocated. Moreover, M-Sharpe ratio maximization confirms our analysis, according between 3% and 72% to fine wine. Without taking count of the risk-profile, between 8% and 70% should be allocated to fine wine assets. However, including those new assets in a portfolio won't make the Sharpe and M-Sharpe ratio increase a lot.

Finally, Table 6 in Section 5.4 provides further confirmation that including fine wines, especially Californian fine wines, improves the performance of a portfolio at a more significant level than in Section 5.3. Indeed, almost 99% of the 400 portfolios created and compared to our reference portfolio have a better Sharpe Ratio or M-Sharpe Ratio than the reference portfolio. Still excluding Liv-ex Investables results. Including Californian fine wines can lead to a Sharpe Ratio that is 0.34 over of the Sharpe Ratio of a traditional portfolio. We also have an improvement in results with the M-Sharpe ratio.

To conclude, and to answer our initial question, "To what extent do fine wines contribute to the performance of a portfolio? Research focused on the Californian territory," our 4 sections suggest that including Californian fine wine in a portfolio does improve its performance. Also, Californian Wine assets are more attractive than global wine assets, offering a higher return and more efficient Return-Risk frontiers. Also, the greatest improvement occurs with lower risk tolerance, where investors can seek higher return for the same level of risk or vice-versa. It is a good alternative asset since there is no correlation between its returns and stock returns. Moreover, studying Sharpe ratio maximization, results suggest that including fine wine assets always allows investors to achieve a higher Sharpe ratio, whether the asset is Californian or global. However, higher Sharpe ratios are achieved with the inclusion of Californian wine in the portfolio compared to global wines. Same conclusions can be drawn with the M-Sharpe Ratio analysis. The quantity to allocate varies depending on the investor's risk profile, the index chosen, and the method used. However, the most difficult task when investing in fine wine for a long period is probably holding the asset and not drinking it.

8. Bibliography

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9. Appendices

9.1 Monthly returns of the different indices used

Date	Liv-ex California	CultX	Liv-ex 50	Liv-ex 100	Liv-ex Invest.	S&P500	S&P MidCap 400	S&P Small Cap	MSCI World	US Bonds
01-01-14										
01-02-14	0,25%	1,19%	-0,20%	-0,92%	-1,39%	4,22%	4,63%	4,26%	4,70%	0,22%
01-03-14	4,38%	-6,78%	-0,63%	-1,39%	-1,11%	0,69%	0,23%	0,57%	-0,09%	0,23%
01-04-14	0,71%	-1,14%	-1,23%	-0,98%	-0,94%	0,62%	-1,65%	-2,89%	0,83%	0,22%
01-05-14	0,47%	0,55%	-1,51%	-1,41%	-1,83%	2,08%	1,61%	0,16%	1,61%	0,21%
01-06-14	-0,71%	-2,57%	-0,75%	-2,97%	-2,07%	1,89%	3,91%	4,47%	1,63%	0,21%
01-07-14	-0,24%	0,37%	-2,43%	-0,86%	-0,49%	-1,52%	-4,44%	-5,72%	-1,68%	0,21%
01-08-14	0,95%	2,27%	-2,79%	0,90%	0,23%	3,70%	4,80%	4,09%	1,98%	0,20%
01-09-14	0,00%	1,90%	-1,01%	0,31%	0,72%	-1,56%	-4,79%	-5,65%	-2,92%	0,21%
01-10-14	0,24%	2,86%	1,26%	0,35%	1,39%	2,29%	3,42%	6,77%	0,57%	0,19%
01-11-14	3,91%	1,85%	-0,58%	0,37%	-0,57%	2,42%	1,67%	-0,40%	1,82%	0,18%
01-12-14	0,23%	0,17%	-0,10%	-0,03%	-0,20%	-0,42%	0,68%	2,66%	-1,73%	0,18%
01-01-15	0,90%	2,35%	-0,15%	1,89%	0,93%	-3,15%	-1,20%	-3,62%	-1,90%	0,14%
01-02-15	2,21%	-1,07%	1,37%	-0,39%	0,06%	5,34%	4,86%	5,74%	5,53%	0,17%
01-03-15	-0,88%	3,06%	0,97%	-0,45%	0,64%	-1,75%	1,15%	1,43%	-1,82%	0,16%
01-04-15	3,04%	-0,73%	-0,35%	0,40%	-0,08%	0,85%	-1,58%	-2,42%	2,14%	0,17%
01-05-15	1,27%	-1,05%	-0,78%	-0,06%	0,34%	1,04%	1,62%	1,40%	0,05%	0,18%
01-06-15	-1,06%	-3,21%	1,07%	0,92%	0,24%	-2,12%	-1,49%	0,88%	-2,49%	0,20%
01-07-15	0,43%	1,60%	0,12%	-1,09%	-0,87%	1,95%	0,05%	-0,92%	1,71%	0,18%
01-08-15	2,72%	-0,44%	-0,01%	0,09%	-0,96%	-6,46%	-5,90%	-5,45%	-7,05%	0,18%
01-09-15	0,41%	3,38%	-0,98%	0,00%	0,48%	-2,68%	-3,44%	-3,72%	-3,94%	0,17%
01-10-15	1,02%	-1,51%	0,25%	-0,60%	1,36%	7,97%	5,39%	5,85%	7,54%	0,18%
01-11-15	1,42%	1,36%	0,19%	-1,47%	1,08%	0,05%	1,17%	2,49%	-0,67%	0,18%

01-12-15	3,55%	0,84%	-1,63%	0,65%	2,13%	-1,77%	-4,42%	-5,08%	-1,88%	0,19%
01-01-16	-3,95%	2,25%	-1,12%	1,09%	1,18%	-5,21%	-5,95%	-6,42%	-6,24%	0,16%
01-02-16	-1,01%	-1,76%	0,98%	1,17%	0,68%	-0,41%	1,24%	0,96%	-0,97%	0,14%
01-03-16	6,50%	3,36%	1,90%	2,60%	2,14%	6,39%	7,99%	7,70%	6,32%	0,15%
01-04-16	-2,12%	0,80%	0,63%	1,05%	4,37%	0,27%	1,13%	1,10%	1,37%	0,15%
01-05-16	0,58%	-0,04%	3,51%	0,62%	2,81%	1,52%	2,13%	1,51%	0,23%	0,15%
01-06-16	3,80%	1,01%	0,89%	2,10%	1,54%	0,09%	0,23%	0,46%	-1,28%	0,12%
01-07-16	3,12%	4,86%	0,59%	3,54%	3,18%	3,50%	4,12%	4,91%	4,06%	0,12%
01-08-16	-1,64%	1,62%	2,61%	2,84%	1,14%	-0,12%	0,34%	1,21%	-0,13%	0,13%
01-09-16	1,46%	-2,63%	5,44%	1,58%	0,17%	-0,12%	-0,80%	0,51%	0,36%	0,13%
01-10-16	2,50%	7,10%	2,63%	3,54%	0,78%	-1,96%	-2,80%	-4,64%	-2,03%	0,15%
01-11-16	0,53%	-1,37%	1,32%	1,64%	0,50%	3,36%	7,53%	11,67%	1,24%	0,20%
01-12-16	1,40%	1,90%	3,68%	0,38%	0,95%	1,80%	2,01%	3,14%	2,26%	0,20%
01-01-17	1,72%	1,08%	0,24%	1,25%	-0,40%	1,77%	1,59%	-0,45%	2,32%	0,21%
01-02-17	0,00%	-1,85%	0,53%	0,39%	0,49%	3,65%	2,47%	1,46%	2,55%	0,20%
01-03-17	1,69%	2,46%	1,04%	0,67%	0,55%	-0,04%	-0,56%	-0,27%	0,81%	0,20%
01-04-17	0,00%	-1,95%	0,19%	-0,53%	0,37%	0,91%	0,76%	0,85%	1,32%	0,19%
01-05-17	-0,17%	-0,46%	1,08%	0,41%	1,00%	1,15%	-0,64%	-2,28%	1,77%	0,18%
01-06-17	4,91%	-0,30%	-0,70%	1,03%	-0,31%	0,48%	1,44%	2,81%	0,25%	0,19%
01-07-17	1,11%	0,64%	1,19%	0,04%	0,49%	1,92%	0,80%	0,90%	2,30%	0,19%
01-08-17	-0,16%	-1,46%	-0,12%	0,47%	0,95%	0,05%	-1,71%	-2,72%	-0,07%	0,18%
01-09-17	0,00%	-0,95%	0,57%	-0,21%	0,04%	1,91%	3,69%	7,29%	2,06%	0,19%
01-10-17	0,00%	2,07%	1,16%	0,29%	0,08%	2,19%	2,16%	0,89%	1,80%	0,20%
01-11-17	0,63%	-0,90%	-0,21%	1,30%	-0,10%	2,77%	3,43%	3,33%	1,97%	0,20%
01-12-17	-0,79%	1,40%	0,25%	-0,09%	-0,31%	0,98%	0,07%	-0,71%	1,25%	0,20%
01-01-18	-0,64%	-1,15%	0,71%	-0,07%	0,25%	5,47%	2,77%	2,44%	5,09%	0,23%
01-02-18	5,13%	-2,56%	0,18%	-0,10%		-3,97%	-4,68%	-4,05%	-4,40%	0,24%
01-03-18	2,40%	0,46%	-0,08%	-0,47%		-2,73%	0,76%	1,84%	-2,44%	0,23%
01-04-18	-1,19%	-1,89%	0,11%	0,31%		0,27%	-0,34%	0,96%	0,95%	0,25%
01-05-18	4,39%	4,85%	-0,60%	0,45%		2,14%	3,87%	6,14%	0,31%	0,24%
01-06-18	2,96%	1,93%	0,27%	1,13%		0,48%	0,27%	0,97%	-0,17%	0,24%

01-07-18	1,93%	2,48%	0,50%	-0,68%	3,54%	1,67%	3,05%	3,01%	0,25%
01-08-18	0,41%	1,46%	1,08%	0,48%	2,98%	2,99%	4,61%	1,03%	0,24%
01-09-18	-1,92%	-1,58%	-0,22%	0,09%	0,43%	-1,24%	-3,37%	0,39%	0,26%
01-10-18	2,19%	0,22%	0,64%	-0,73%	-7,19%	-10,12%	-11,14%	-7,71%	0,26%
01-11-18	3,20%	0,69%	-0,07%	-0,18%	1,77%	2,89%	1,36%	0,95%	0,25%
01-12-18	0,00%	2,33%	-1,57%	-0,42%	-9,63%	-12,19%	-13,07%	-8,03%	0,22%
01-01-19	-1,85%	-1,19%	-0,68%	-0,02%	7,57%	9,86%	10,03%	7,39%	0,22%
01-02-19	-0,13%	-0,11%	-0,63%	-0,71%	2,93%	4,00%	4,15%	2,79%	0,23%
01-03-19	-7,65%	1,16%	0,05%	-0,25%	1,78%	-0,74%	-3,60%	1,04%	0,20%
01-04-19	0,00%	0,11%	-0,49%	-0,15%	3,86%	3,85%	3,74%	3,31%	0,21%
01-05-19	-0,58%	0,19%	-0,27%	-0,18%	-6,80%	-8,48%	-9,27%	-6,27%	0,18%
01-06-19	6,31%	1,87%	-0,18%	0,39%	6,67%	7,19%	7,01%	6,26%	0,17%
01-07-19	0,43%	-0,93%	0,05%	0,27%	1,30%	1,08%	1,06%	0,42%	0,17%
01-08-19	0,28%	0,52%	-0,07%	0,74%	-1,83%	-4,45%	-4,75%	-2,27%	0,12%
01-09-19	0,63%	0,07%	0,77%	-0,33%	1,70%	2,84%	3,11%	1,92%	0,14%
01-10-19	-0,14%	-1,73%	0,25%	-0,96%	2,02%	1,02%	1,84%	2,42%	0,14%
01-11-19	-0,92%	-1,44%	-0,33%	-1,29%	3,35%	2,76%	2,88%	2,60%	0,15%
01-12-19	-1,14%	-3,35%	-1,69%	-0,61%	2,82%	2,60%	2,75%	2,85%	0,16%
01-01-20	-0,79%	2,20%	-1,64%	-0,23%	-0,16%	-2,74%	-4,13%	-0,68%	0,13%
01-02-20	-0,29%	0,57%	-0,54%	0,23%	-8,79%	-10,12%	-10,21%	-8,99%	0,10%
01-03-20	0,22%	-0,84%	-0,85%	-1,06%	-13,37%	-22,85%	-25,62%	-14,47%	0,06%
01-04-20	-1,02%	3,85%	-1,01%	-0,30%	11,94%	13,16%	11,86%	10,26%	0,05%
01-05-20	-0,29%	-1,33%	-2,55%	-0,74%	4,43%	6,90%	4,07%	4,53%	0,05%
01-06-20	-0,74%	5,15%	1,03%	-0,22%	1,82%	1,09%	3,52%	2,48%	0,05%
01-07-20	1,03%	3,93%	1,90%	1,48%	5,36%	4,43%	3,95%	4,58%	0,04%
01-08-20	0,87%	-0,66%	1,10%	0,75%	6,77%	3,30%	3,79%	6,33%	0,06%
01-09-20	1,37%	1,49%	0,67%	1,56%	-4,00%	-3,45%	-4,96%	-3,66%	0,06%
01-10-20	1,35%	-0,89%	0,55%	2,25%	-2,81%	2,07%	2,46%	-3,19%	0,07%
01-11-20	1,19%	-0,26%	0,42%	0,84%	10,21%	13,21%	16,56%	11,92%	0,07%
01-12-20	0,83%	-0,47%	1,40%	0,74%	3,64%	6,17%	7,84%	4,06%	0,08%
01-01-21	0,76%	0,62%	0,45%	0,59%	-1,12%	1,44%	6,05%	-1,06%	0,09%

01-02-21	0,62%	-1,75%	0,29%	0,66%	2,58%	6,46%	7,29%	2,42%	0,12%
01-03-21	0,54%	-4,42%	0,02%	1,51%	4,16%	4,43%	3,14%	3,06%	0,15%
01-04-21	1,62%	-0,36%	0,63%	1,50%	5,11%	4,35%	1,97%	4,42%	0,14%
01-05-21	1,52%	-1,11%	1,60%	0,72%	0,55%	0,08%	1,94%	1,25%	0,13%
01-06-21	0,72%	0,23%	1,40%	0,76%	2,20%	-1,15%	0,21%	1,39%	0,12%
01-07-21	0,78%	0,37%	0,04%	2,56%	2,25%	0,28%	-2,47%	1,71%	0,10%
01-08-21	2,75%	1,31%	1,20%	1,25%	2,86%	1,81%	1,88%	2,32%	0,11%
01-09-21	1,56%	1,46%	2,71%	3,78%	-4,87%	-4,18%	-2,60%	-4,38%	0,12%
01-10-21	3,54%	1,70%	1,32%	2,17%	6,69%	5,65%	3,31%	5,44%	0,13%
01-11-21	2,25%	2,26%	2,13%	2,80%	-0,84%	-3,11%	-2,45%	-2,32%	0,12%
01-12-21	2,66%	1,36%	0,12%	2,58%	4,27%	4,81%	4,27%	4,10%	0,13%
01-01-22	2,48%	1,55%	0,89%	1,77%	-5,40%	-7,55%	-7,59%	-5,49%	0,15%
01-02-22	1,66%	3,59%	0,62%	0,35%	-3,19%	0,99%	1,29%	-2,69%	0,15%
01-03-22	0,44%	-2,94%	0,85%	0,65%	3,51%	1,20%	0,18%	2,49%	0,20%
01-04-22	0,60%	4,60%	0,82%	0,69%	-9,21%	-7,45%	-8,20%	-8,81%	0,24%
01-05-22	0,70%	1,65%	0,78%	0,71%	0,01%	0,58%	1,71%	-0,17%	0,24%
01-06-22	0,75%	0,30%	0,08%	0,68%	-8,77%	-10,29%	-9,11%	-9,18%	0,25%
01-07-22	0,43%	1,33%	0,71%	-0,31%	8,72%	10,21%	9,47%	7,57%	0,22%
01-08-22	0,05%	0,63%	-0,02%	1,30%	-4,34%	-3,30%	-4,62%	-4,43%	0,27%
01-09-22	1,42%	1,98%	-1,03%	1,85%	-9,80%	-9,83%	-10,60%	-9,94%	0,32%
01-10-22	1,25%	2,24%	0,72%	-0,55%	7,68%	9,91%	11,57%	6,87%	0,34%
01-11-22	-0,52%	-0,28%	1,35%	-0,37%	5,24%	5,78%	3,92%	6,58%	0,30%
01-12-22	-0,26%	-0,85%	-0,35%	-0,22%	-6,08%	-5,89%	-7,16%	-4,44%	0,32%
01-01-23	-0,52%	2,59%	-0,87%	-1,39%	5,99%	8,75%	8,99%	6,77%	0,29%
01-02-23	-0,95%	-1,70%	0,00%	0,36%	-2,65%	-1,97%	-1,36%	-2,56%	0,33%
01-03-23	0,32%	1,47%		0,19%	3,45%	-3,47%	-5,53%	2,79%	0,29%
01-04-23	-0,05%	-0,43%		0,01%	1,45%	-0,87%	-2,91%	1,58%	0,29%
01-05-23	-1,01%	1,16%		-0,51%	0,25%	-3,42%	-1,96%	-1,26%	0,30%
01-06-23	-2,54%	-1,19%		-2,03%	6,27%	8,58%	7,72%	5,76%	0,32%
01-07-23	-2,88%	0,11%		-6,17%	3,07%	3,97%	5,29%	3,24%	0,33%
01-08-23	-2,56%	-3,08%		-1,28%	-1,79%	-3,09%	-4,43%	-2,59%	0,34%

01-09-23	-0,81%	0,71%	-0,06%	-4,99%	-5,57%	-6,36%	-4,55%	0,38%
01-10-23	-0,88%	0,26%	-1,90%	-2,22%	-5,58%	-6,01%	-3,01%	0,41%
01-11-23	-1,72%	-0,25%	-1,35%	8,54%	8,01%	7,68%	8,81%	0,36%
01-12-23	-1,26%	-0,95%	-1,08%	4,33%	8,16%	11,87%	4,70%	0,32%
01-01-24	-0,61%	-0,34%	-0,31%	1,58%	-1,77%	-4,11%	1,13%	0,33%

Note: Data here for Liv-ex 50 have been shortened to a monthly basis to avoid an extra-long table.

9.2 Mean-Variance efficient frontier results

Reference		Liv-ex California		Cultx		Liv-ex 100	
Var	Return	Var	Return	Var	Return	Var	Return
0,000%	0,193%	0,000%	0,196%	0,000%	0,194%	0,000%	0,195%
0,025%	0,399%	0,025%	0,579%	0,025%	0,451%	0,025%	0,462%
0,050%	0,522%	0,050%	0,723%	0,050%	0,612%	0,050%	0,562%
0,075%	0,597%	0,075%	0,753%	0,075%	0,674%	0,075%	0,630%
0,100%	0,659%	0,100%	0,776%	0,100%	0,719%	0,100%	0,684%
0,125%	0,714%	0,125%	0,794%	0,125%	0,756%	0,125%	0,731%
0,150%	0,764%	0,150%	0,810%	0,150%	0,788%	0,150%	0,773%
0,175%	0,810%	0,175%	0,825%	0,175%	0,817%	0,175%	0,811%

Liv-ex Investables		Reference (adjusted period)		Liv-ex 50		Reference (adjusted period)	
Var	Returns	Var	Returns	Var	Returns	Var	Returns
0,000%	0,185%	0,000%	0,182%	0,000%	0,178%	0,000%	0,177%
0,010%	0,541%	0,010%	0,466%	0,025%	0,434%	0,025%	0,388%
0,020%	0,681%	0,020%	0,583%	0,050%	0,523%	0,050%	0,475%
0,030%	0,759%	0,030%	0,674%	0,075%	0,582%	0,075%	0,542%
0,040%	0,816%	0,040%	0,750%	0,100%	0,629%	0,100%	0,598%
0,050%	0,864%	0,050%	0,818%	0,125%	0,670%	0,125%	0,648%

0,060%	0,905%	0,060%	0,878%	0,150%	0,707%	0,150%	0,693%
0,070%	0,943%	0,070%	0,934%	0,175%	0,740%	0,175%	0,734%

9.3 Mean-Modified Value-at-Risk (M-MVaR) efficient frontiers results

Reference		Liv-ex California		Cultx		Liv-ex 100	
M-MVaR	Return	M-MVaR	Return	M-MVaR	Return	M-MVaR	Return
0,3%	0,2%	0,3%	0,2%	0,3%	0,2%	0,3%	0,2%
1,0%	0,2%	1,0%	0,3%	1,0%	0,3%	1,0%	0,3%
2,0%	0,3%	2,0%	0,4%	2,0%	0,4%	2,0%	0,4%
3,0%	0,3%	3,0%	0,6%	3,0%	0,5%	3,0%	0,5%
4,0%	0,4%	4,0%	0,7%	4,0%	0,6%	4,0%	0,6%
5,0%	0,4%	5,0%	0,7%	5,0%	0,7%	5,0%	0,6%
6,0%	0,5%	6,0%	0,8%	6,0%	0,7%	6,0%	0,7%
7,0%	0,5%	7,0%	0,8%	7,0%	0,8%	7,0%	0,8%

Liv-ex Investables		Reference (adjusted period)		Liv-ex 50		Reference (adjusted period)	
M-MVaR	Return	M-MVaR	Return	M-MVaR	Return	M-MVaR	Return
0,2%	0,2%	0,2%	0,2%	0,3%	0,2%	0,3%	0,2%
1,0%	0,3%	1,0%	0,3%	1,0%	0,3%	1,0%	0,2%
2,0%	0,5%	2,0%	0,4%	2,0%	0,3%	2,0%	0,3%
3,0%	0,7%	3,0%	0,6%	3,0%	0,4%	3,0%	0,4%
4,0%	0,8%	4,0%	0,7%	4,0%	0,5%	4,0%	0,5%
5,0%	0,9%	5,0%	0,9%	5,0%	0,6%	5,0%	0,5%
				6,0%	0,6%	6,0%	0,6%

9.4 Sharpe ratio maximization results

9.4.1. Liv-ex 50 California as an alternative asset

9.4.1.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	19%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	76%
Liv-ex California	0,23%	0,03%	1,82%	5%
				100,00%

Portfolio Results	
Return	0,341%
Var	0,007%
STDS	0,835%
Sharpe Ratio	1,18

9.4.1.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	18%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	54%
Liv-ex California	0,23%	0,03%	1,82%	11%
				100,00%

Portfolio Results	
Return	0,405%
Var	0,028%
STDS	1,676%
Sharpe Ratio	1,13

9.4.1.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	26%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	9%
US Bonds	0,19%	0,00%	0,10%	34%
Liv-ex California	0,23%	0,03%	1,82%	14%
				100%

Portfolio Results	
Return	0,515%
Var	0,054%
STDS	2,318%
Sharpe Ratio	1,14

9.4.1.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	33%
S&P MidCap 400	0,66%	0,42%	6,45%	12%
S&P Small Cap	0,51%	0,49%	6,99%	12%
MSCI World	0,76%	0,27%	5,23%	8%
US Bonds	0,19%	0,00%	0,10%	16%
Liv-ex California	0,23%	0,03%	1,82%	18%
				100%

Portfolio Results	
Return	0,599%
Var	0,089%
STDS	2,983%
Sharpe Ratio	1,14

9.4.1.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	31%
S&P MidCap 400	0,66%	0,42%	6,45%	16%
S&P Small Cap	0,51%	0,49%	6,99%	16%
MSCI World	0,76%	0,27%	5,23%	16%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex California	0,23%	0,03%	1,82%	22%
				100%

Portfolio Results	
Return	0,655%
Var	0,126%
STDS	3,546%
Sharpe Ratio	1,13

9.4.1.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	17%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	79%
Liv-ex California	0,23%	0,03%	1,82%	4%

Portfolio Results	
Return	0,322%
Var	0,005%
STDS	0,727%
Sharpe Ratio	1,18

9.4.2. CultX as an alternative asset

9.4.2.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	16%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	65%
Cultx	0,38%	0,03%	1,87%	19%
				100%

Portfolio Results	
Return	0,354%
Var	0,006%
STDS	0,786%
Sharpe Ratio	1,21

9.4.2.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	12%
S&P MidCap 400	0,66%	0,42%	6,45%	6%
S&P Small Cap	0,51%	0,49%	6,99%	6%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	36%
Cultx	0,38%	0,03%	1,87%	40%
				100%

Portfolio Results	
Return	0,408%
Var	0,018%
STDS	1,354%
Sharpe Ratio	1,16

9.4.2.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	16%
S&P MidCap 400	0,66%	0,42%	6,45%	5%
S&P Small Cap	0,51%	0,49%	6,99%	5%
MSCI World	0,76%	0,27%	5,23%	5%
US Bonds	0,19%	0,00%	0,10%	21%
Cultx	0,38%	0,03%	1,87%	47%
				100%

Portfolio Results	
Return	0,477%
Var	0,028%
STDS	1,670%
Sharpe Ratio	1,17

9.4.2.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	18%
S&P MidCap 400	0,66%	0,42%	6,45%	7%
S&P Small Cap	0,51%	0,49%	6,99%	7%
MSCI World	0,76%	0,27%	5,23%	4%
US Bonds	0,19%	0,00%	0,10%	9%
Cultx	0,38%	0,03%	1,87%	55%
				100%

Portfolio Results	
Return	0,515%
Var	0,037%
STDS	1,926%
Sharpe Ratio	1,17

9.4.2.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	15%
S&P MidCap 400	0,66%	0,42%	6,45%	8%
S&P Small Cap	0,51%	0,49%	6,99%	8%
MSCI World	0,76%	0,27%	5,23%	8%
US Bonds	0,19%	0,00%	0,10%	0%
Cultx	0,38%	0,03%	1,87%	62%
				100%

Portfolio Results	
Return	0,533%
Var	0,044%
STDS	2,095%
Sharpe Ratio	1,16

9.4.1.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	11%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	77%
CultX	0,38%	0,03%	1,87%	13%

Portfolio Results	
Return	0,298%
Var	0,003%
STDS	0,520%
Sharpe Ratio	1,21

9.4.3. Liv-ex 100 as an alternative asset

9.4.3.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	17%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	67%
Liv-ex 100	0,24%	0,02%	1,46%	17%
				100%

Portfolio Results	
Returns	0,328%
Var	0,005%
STDS	0,731%
Sharpe Ratio	1,19

9.4.3.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	13%
S&P MidCap 400	0,66%	0,42%	6,45%	7%
S&P Small Cap	0,51%	0,49%	6,99%	7%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	40%
Liv-ex 100	0,24%	0,02%	1,46%	33%
				100%

Portfolio Results	
Returns	0,363%
Var	0,016%
STDS	1,284%
Sharpe Ratio	1,13

9.4.3.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	18%
S&P MidCap 400	0,66%	0,42%	6,45%	6%
S&P Small Cap	0,51%	0,49%	6,99%	6%
MSCI World	0,76%	0,27%	5,23%	6%
US Bonds	0,19%	0,00%	0,10%	24%
Liv-ex 100	0,24%	0,02%	1,46%	40%
				100%

Portfolio Results	
Returns	0,431%
Var	0,027%
STDS	1,640%
Sharpe Ratio	1,15

9.4.3.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	21%
S&P MidCap 400	0,66%	0,42%	6,45%	8%
S&P Small Cap	0,51%	0,49%	6,99%	8%
MSCI World	0,76%	0,27%	5,23%	5%
US Bonds	0,19%	0,00%	0,10%	11%
Liv-ex 100	0,24%	0,02%	1,46%	47%
				100%

Portfolio Results	
Returns	0,469%
Var	0,038%
STDS	1,943%
Sharpe Ratio	1,14

9.4.3.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	19%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	9%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex 100	0,24%	0,02%	1,46%	54%
				100%

Portfolio Results	
Returns	0,486%
Var	0,046%
STDS	2,150%
Sharpe Ratio	1,14

9.4.3.5 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	7%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	84%
Liv-ex 100	0,24%	0,02%	1,46%	8%
				100%

Portfolio Results	
Returns	0,250%
Var	0,001%
STDS	0,312%
Sharpe Ratio	1,19

9.4.4. Liv-ex Investables as an alternative asset

9.4.4.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	13%
S&P MidCap 400	1,64%	0,06%	2,52%	0%
S&P Small Cap	1,75%	0,12%	3,49%	0%
MSCI World	1,45%	0,04%	1,90%	0%
US Bonds	0,18%	0,00%	0,03%	52%
Liv-ex Invest	0,89%	0,01%	1,18%	35%
				100%

Portfolio Results	
Returns	0,606%
Var	0,003%
STDS	0,551%
Sharpe Ratio	1,78

9.4.4.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	10%
S&P MidCap 400	1,64%	0,06%	2,52%	5%
S&P Small Cap	1,75%	0,12%	3,49%	5%
MSCI World	1,45%	0,04%	1,90%	0%
US Bonds	0,18%	0,00%	0,03%	29%
Liv-ex Invest	0,89%	0,01%	1,18%	52%
				100%

Portfolio Results	
Returns	0,827%
Var	0,007%
STDS	0,844%
Sharpe Ratio	1,77

9.4.4.3 Balance Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	12%
S&P MidCap 400	1,64%	0,06%	2,52%	4%
S&P Small Cap	1,75%	0,12%	3,49%	4%
MSCI World	1,45%	0,04%	1,90%	4%
US Bonds	0,18%	0,00%	0,03%	16%
Liv-ex Invest	0,89%	0,01%	1,18%	60%
				100%

Portfolio Results	
Returns	0,943%
Var	0,010%
STDS	0,987%
Sharpe Ratio	1,78

9.4.4.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	13%
S&P MidCap 400	1,64%	0,06%	2,52%	5%
S&P Small Cap	1,75%	0,12%	3,49%	5%
MSCI World	1,45%	0,04%	1,90%	3%
US Bonds	0,18%	0,00%	0,03%	7%
Liv-ex Invest	0,89%	0,01%	1,18%	67%
				100%

Portfolio Results	
Returns	1,029%
Var	0,012%
STDS	1,100%
Sharpe Ratio	1,78

9.4.4.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	11%
S&P MidCap 400	1,64%	0,06%	2,52%	6%
S&P Small Cap	1,75%	0,12%	3,49%	6%
MSCI World	1,45%	0,04%	1,90%	6%
US Bonds	0,18%	0,00%	0,03%	0%
Liv-ex Invest	0,89%	0,01%	1,18%	72%
				100%

Portfolio Results	
Returns	1,086%
Var	0,014%
STDS	1,178%
Sharpe Ratio	1,77

9.4.4. Fully Optimized

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	1%
S&P MidCap 400	1,64%	0,06%	2,52%	0%
S&P Small Cap	1,75%	0,12%	3,49%	0%
MSCI World	1,45%	0,04%	1,90%	0%
US Bonds	0,18%	0,00%	0,03%	94%
Liv-ex Invest	0,89%	0,01%	1,18%	5%
				100%

Portfolio Results	
Returns	0,229%
Var	0,000%
STDS	0,064%
Sharpe Ratio	1,83

9.4.5. Liv-ex 50 as an alternative asset

9.4.5.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	14%
S&P MidCap 400	0,54%	0,47%	6,88%	0%
S&P Small Cap	0,35%	0,54%	7,36%	0%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	58%
Liv-ex 50	0,25%	0,01%	1,01%	28%
				100%

Portfolio Results	
Returns	0,264%
Var	0,006%
STDS	0,746%
Sharpe Ratio	1,13

9.4.5.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	9%
S&P MidCap 400	0,54%	0,47%	6,88%	5%
S&P Small Cap	0,35%	0,54%	7,36%	5%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	28%
Liv-ex 50	0,25%	0,01%	1,01%	54%
				100%

Portfolio Results	
Return	0,284%
Var	0,013%
STDS	1,147%
Sharpe Ratio	1,10

9.4.5.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	12%
S&P MidCap 400	0,54%	0,47%	6,88%	4%
S&P Small Cap	0,35%	0,54%	7,36%	4%
MSCI World	0,48%	0,31%	5,52%	4%
US Bonds	0,16%	0,00%	0,08%	15%
Liv-ex 50	0,25%	0,01%	1,01%	61%
				100%

Portfolio Results	
Return	0,311%
Var	0,018%
STDS	1,354%
Sharpe Ratio	1,11

9.4.5.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	13%
S&P MidCap 400	0,54%	0,47%	6,88%	5%
S&P Small Cap	0,35%	0,54%	7,36%	5%
MSCI World	0,48%	0,31%	5,52%	3%
US Bonds	0,16%	0,00%	0,08%	6%
Liv-ex 50	0,25%	0,01%	1,01%	68%
				100%

Portfolio Results	
Return	0,325%
Var	0,022%
STDS	1,498%
Sharpe Ratio	1,11

9.4.5.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	10%
S&P MidCap 400	0,54%	0,47%	6,88%	5%
S&P Small Cap	0,35%	0,54%	7,36%	5%
MSCI World	0,48%	0,31%	5,52%	5%
US Bonds	0,16%	0,00%	0,08%	0%
Liv-ex 50	0,25%	0,01%	1,01%	74%
				100%

Portfolio Results	
Return	0,326%
Var	0,024%
STDS	1,562%
Sharpe Ratio	1,10

9.4.5.5 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	6%
S&P MidCap 400	0,54%	0,47%	6,88%	0%
S&P Small Cap	0,35%	0,54%	7,36%	0%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	82%
Liv-ex 50	0,25%	0,01%	1,01%	12%
				100%

Portfolio Results	
Return	0,206%
Var	0,001%
STDS	0,314%
Sharpe Ratio	1,13

9.5 M-Sharpe ratio maximization results

9.5.1 Liv-ex 50 California as an alternative asset

9.5.1.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	19%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	78%
Liv-ex California	0,23%	0,03%	1,82%	3%
				100,00%

Portfolio Results	
Return	0,343%
Var	0,007%
STDS	0,849%
MVaR	1,739%
M-Sharpe	1,09

9.5.1.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	19%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	56%
Liv-ex California	0,23%	0,03%	1,82%	7%
				100,00%

Portfolio Results	
Return	0,412%
Var	0,030%
STDS	1,741%
MVaR	3,276%
M-Sharpe	1,07

9.5.1.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	28%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	9%
US Bonds	0,19%	0,00%	0,10%	37%
Liv-ex California	0,23%	0,03%	1,82%	8%
				100%

Portfolio Results	
Return	0,535%
Var	0,061%
STDS	2,461%
MVaR	4,582%
M-Sharpe	1,08

9.5.1.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	36%
S&P MidCap 400	0,66%	0,42%	6,45%	13%
S&P Small Cap	0,51%	0,49%	6,99%	13%
MSCI World	0,76%	0,27%	5,23%	9%
US Bonds	0,19%	0,00%	0,10%	18%
Liv-ex California	0,23%	0,03%	1,82%	10%
				100%

Portfolio Results	
Return	0,633%
Var	0,105%
STDS	3,237%
MVaR	5,957%
M-Sharpe	1,07

9.5.1.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	35%
S&P MidCap 400	0,66%	0,42%	6,45%	17%
S&P Small Cap	0,51%	0,49%	6,99%	17%
MSCI World	0,76%	0,27%	5,23%	17%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex California	0,23%	0,03%	1,82%	13%
				100%

Portfolio Results	
Return	0,703%
Var	0,154%
STDS	3,919%
MVaR	7,150%
M-Sharpe	1,07

9.5.1.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	92%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex California	0,23%	0,03%	1,82%	8%
				100%

Portfolio Results	
Return	0,911%
Var	0,161%
STDS	4,010%
MVaR	7,507%
M-Sharpe	1,10

9.5.2 CultX as an alternative asset

9.5.2.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	16%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	64%
Cultx	0,38%	0,03%	1,87%	20%
				100%

Portfolio Results	
Returns	0,354%
Var	0,006%
STDS	0,787%
MVaR	1,649%
M-Sharpe	1,10

9.5.2.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	12%
S&P MidCap 400	0,66%	0,42%	6,45%	6%
S&P Small Cap	0,51%	0,49%	6,99%	6%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	36%
Cultx	0,38%	0,03%	1,87%	40%
				100%

Portfolio Results	
Returns	0,408%
Var	0,018%
STDS	1,355%
MVaR	2,637%
M-Sharpe	1,08

9.5.2.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	16%
S&P MidCap 400	0,66%	0,42%	6,45%	5%
S&P Small Cap	0,51%	0,49%	6,99%	5%
MSCI World	0,76%	0,27%	5,23%	5%
US Bonds	0,19%	0,00%	0,10%	22%
Cultx	0,38%	0,03%	1,87%	46%
				100%

Portfolio Results	
Returns	0,479%
Var	0,028%
STDS	1,682%
MVaR	3,245%
M-Sharpe	1,09

9.5.2.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	18%
S&P MidCap 400	0,66%	0,42%	6,45%	7%
S&P Small Cap	0,51%	0,49%	6,99%	7%
MSCI World	0,76%	0,27%	5,23%	5%
US Bonds	0,19%	0,00%	0,10%	9%
Cultx	0,38%	0,03%	1,87%	54%
				100%

Portfolio Results	
Returns	0,519%
Var	0,038%
STDS	1,951%
MVaR	3,729%
M-Sharpe	1,09

9.5.2.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	16%
S&P MidCap 400	0,66%	0,42%	6,45%	8%
S&P Small Cap	0,51%	0,49%	6,99%	8%
MSCI World	0,76%	0,27%	5,23%	8%
US Bonds	0,19%	0,00%	0,10%	0%
Cultx	0,38%	0,03%	1,87%	60%
				100%

Portfolio Results	
Returns	0,539%
Var	0,045%
STDS	2,131%
MVaR	4,044%
M-Sharpe	1,09

9.5.2.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	48%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	0%
Cultx	0,38%	0,03%	1,87%	52%
				100%

Portfolio Results	
Returns	0,665%
Var	0,053%
STDS	2,302%
MVaR	4,452%
M-Sharpe	1,11

9.5.3. Liv-ex 100 as an alternative asset

9.5.3.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	17%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	69%
Liv-ex 100	0,24%	0,02%	1,46%	14%
				100%

Portfolio Results	
Returns	0,331%
Var	0,006%
STDS	0,749%
MVaR	1,564%
M-Sharpe	1,09

9.5.3.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	14%
S&P MidCap 400	0,66%	0,42%	6,45%	7%
S&P Small Cap	0,51%	0,49%	6,99%	7%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	43%
Liv-ex 100	0,24%	0,02%	1,46%	28%
				100%

Portfolio Results	
Returns	0,372%
Var	0,018%
STDS	1,354%
MVaR	2,599%
M-Sharpe	1,07

9.5.3.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	20%
S&P MidCap 400	0,66%	0,42%	6,45%	7%
S&P Small Cap	0,51%	0,49%	6,99%	7%
MSCI World	0,76%	0,27%	5,23%	7%
US Bonds	0,19%	0,00%	0,10%	26%
Liv-ex 100	0,24%	0,02%	1,46%	34%
				100%

Portfolio Results	
Returns	0,451%
Var	0,032%
STDS	1,780%
MVaR	3,379%
M-Sharpe	1,08

9.5.3.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	24%
S&P MidCap 400	0,66%	0,42%	6,45%	9%
S&P Small Cap	0,51%	0,49%	6,99%	9%
MSCI World	0,76%	0,27%	5,23%	6%
US Bonds	0,19%	0,00%	0,10%	12%
Liv-ex 100	0,24%	0,02%	1,46%	41%
				100%

Portfolio Results	
Returns	0,499%
Var	0,046%
STDS	2,156%
MVaR	4,045%
M-Sharpe	1,08

9.5.3.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	21%
S&P MidCap 400	0,66%	0,42%	6,45%	11%
S&P Small Cap	0,51%	0,49%	6,99%	11%
MSCI World	0,76%	0,27%	5,23%	11%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex 100	0,24%	0,02%	1,46%	47%
				100%

Portfolio Results	
Returns	0,523%
Var	0,059%
STDS	2,421%
MVaR	4,505%
M-Sharpe	1,07

9.5.3.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,97%	0,28%	5,28%	60%
S&P MidCap 400	0,66%	0,42%	6,45%	0%
S&P Small Cap	0,51%	0,49%	6,99%	0%
MSCI World	0,76%	0,27%	5,23%	0%
US Bonds	0,19%	0,00%	0,10%	0%
Liv-ex 100	0,24%	0,02%	1,46%	40%
				100%

Portfolio Results	
Returns	0,678%
Var	0,069%
STDS	2,628%
MVaR	5,001%
M-Sharpe	1,10

9.5.4. Liv-ex Investables as an alternative asset

9.5.4.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	12%
S&P MidCap 400	1,64%	0,06%	2,52%	0%
S&P Small Cap	1,75%	0,12%	3,49%	0%
MSCI World	1,45%	0,04%	1,90%	0%
US Bonds	0,18%	0,00%	0,03%	49%
Liv-ex Invest	0,89%	0,01%	1,18%	39%
				100%

Portfolio Results	
Returns	0,625%
Var	0,003%
STDS	0,578%
MVaR	1,576%
M-Sharpe	1,28

9.5.4.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	9%
S&P MidCap 400	1,64%	0,06%	2,52%	5%
S&P Small Cap	1,75%	0,12%	3,49%	5%
MSCI World	1,45%	0,04%	1,90%	0%
US Bonds	0,18%	0,00%	0,03%	28%
Liv-ex Invest	0,89%	0,01%	1,18%	53%
				100%

Portfolio Results	
Returns	0,828%
Var	0,007%
STDS	0,845%
MVaR	2,217%
M-Sharpe	1,29

9.5.4.3 Balance Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	12%
S&P MidCap 400	1,64%	0,06%	2,52%	4%
S&P Small Cap	1,75%	0,12%	3,49%	4%
MSCI World	1,45%	0,04%	1,90%	4%
US Bonds	0,18%	0,00%	0,03%	16%
Liv-ex Invest	0,89%	0,01%	1,18%	60%
				100%

Portfolio Results	
Returns	0,944%
Var	0,010%
STDS	0,988%
MVaR	2,568%
M-Sharpe	1,30

9.5.4.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	13%
S&P MidCap 400	1,64%	0,06%	2,52%	5%
S&P Small Cap	1,75%	0,12%	3,49%	5%
MSCI World	1,45%	0,04%	1,90%	3%
US Bonds	0,18%	0,00%	0,03%	7%
Liv-ex Invest	0,89%	0,01%	1,18%	66%
				100%

Portfolio Results	
Returns	1,033%
Var	0,012%
STDS	1,106%
MVaR	2,852%
M-Sharpe	1,30

9.5.4.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	12%
S&P MidCap 400	1,64%	0,06%	2,52%	6%
S&P Small Cap	1,75%	0,12%	3,49%	6%
MSCI World	1,45%	0,04%	1,90%	6%
US Bonds	0,18%	0,00%	0,03%	0%
Liv-ex Invest	0,89%	0,01%	1,18%	71%
				100%

Portfolio Results	
Returns	1,095%
Var	0,014%
STDS	1,190%
MVaR	3,053%
M-Sharpe	1,30

9.5.4.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	1,56%	0,04%	1,92%	20%
S&P MidCap 400	1,64%	0,06%	2,52%	7%
S&P Small Cap	1,75%	0,12%	3,49%	0%
MSCI World	1,45%	0,04%	1,90%	2%
US Bonds	0,18%	0,00%	0,03%	0%
Liv-ex Invest	0,89%	0,01%	1,18%	70%
				100%

Portfolio Results	
Returns	1,095%
Var	0,014%
STDS	1,177%
MVaR	3,031%
M-Sharpe	1,30

9.5.5. Liv-ex 50 as an alternative asset

9.5.5.1. Conservative Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	15%
S&P MidCap 400	0,54%	0,47%	6,88%	0%
S&P Small Cap	0,35%	0,54%	7,36%	0%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	58%
Liv-ex 50	0,25%	0,01%	1,01%	27%
				100%

Portfolio Results	
Returns	0,264%
Var	0,006%
STDS	0,746%
MVaR	1,491%
M-Sharpe	1,07

9.5.5.2 Moderately Conservative Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	10%
S&P MidCap 400	0,54%	0,47%	6,88%	5%
S&P Small Cap	0,35%	0,54%	7,36%	5%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	29%
Liv-ex 50	0,25%	0,01%	1,01%	52%
				100%

Portfolio Results	
Returns	0,286%
Var	0,013%
STDS	1,160%
MVaR	2,195%
M-Sharpe	1,06

9.5.5.3 Balance Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	12%
S&P MidCap 400	0,54%	0,47%	6,88%	4%
S&P Small Cap	0,35%	0,54%	7,36%	4%
MSCI World	0,48%	0,31%	5,52%	4%
US Bonds	0,16%	0,00%	0,08%	16%
Liv-ex 50	0,25%	0,01%	1,01%	59%
				100%

Portfolio Results	
Returns	0,315%
Var	0,019%
STDS	1,391%
MVaR	2,604%
M-Sharpe	1,06

9.5.5.4 Moderately Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	14%
S&P MidCap 400	0,54%	0,47%	6,88%	5%
S&P Small Cap	0,35%	0,54%	7,36%	5%
MSCI World	0,48%	0,31%	5,52%	3%
US Bonds	0,16%	0,00%	0,08%	7%
Liv-ex 50	0,25%	0,01%	1,01%	66%
				100%

Portfolio Results	
Returns	0,332%
Var	0,024%
STDS	1,557%
MVaR	2,893%
M-Sharpe	1,06

9.5.5.5 Aggressive Profile

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	11%
S&P MidCap 400	0,54%	0,47%	6,88%	6%
S&P Small Cap	0,35%	0,54%	7,36%	6%
MSCI World	0,48%	0,31%	5,52%	6%
US Bonds	0,16%	0,00%	0,08%	0%
Liv-ex 50	0,25%	0,01%	1,01%	72%
				100%

Portfolio Results	
Returns	0,333%
Var	0,027%
STDS	1,631%
MVaR	3,017%
M-Sharpe	1,06

9.5.5.6 Fully Optimized

	Return	Var	STD	Weights
S&P500	0,68%	0,32%	5,66%	38%
S&P MidCap 400	0,54%	0,47%	6,88%	0%
S&P Small Cap	0,35%	0,54%	7,36%	0%
MSCI World	0,48%	0,31%	5,52%	0%
US Bonds	0,16%	0,00%	0,08%	0%
Liv-ex 50	0,25%	0,01%	1,01%	62%
				100%

Portfolio Results	
Returns	0,416%
Var	0,036%
STDS	1,904%
MVaR	3,547%
M-Sharpe	1,07

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