Mitigating downside risk of portfolio diversification: Wine versus other tangible assets

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- ***Manuscript*: Color should be used for:**
  - Figure 2. Histograms of the original and Geltner liquidity-adjusted wine return series

- Figure 3. Index levels and drawdowns

Abstract

Investors increasingly use tangible assets and especially wine to reduce the volatility of their portfolios through improved diversification. However, these assets are long-horizon investments, and therefore, short-term fluctuations (volatility) are of little relevance. Instead, assessing if these assets reduce the risk of facing severe losses (downside risk) appears more appropriate. Unfortunately, literature offers little guidance on this issue. To address this, we analyze portfolios containing both traditional and tangible assets. Our results demonstrate that wine not only presents a lower downside risk than most other tangible assets but also reduces portfolios' downside risk. This is due to wine-market specific factors driving wine returns and thus disconnecting them from other asset returns. We also show that gold presents similar advantages as wine and that combining these two assets may further enhance their effect. Overall, allocating around 10% of a portfolio to wine seems sensible from a downside risk management perspective.

JEL Classification: C60, G11, Q11

Keywords: fine wines, tangible assets, alternative investments, downside risk, extreme returns

"I could not live without Champagne. In victory I deserve it. In defeat I need it" (W. Churchill)

1 Introduction

Since the Global Financial Crisis, investors have been on the hunt for new, exotic asset classes to include in their portfolio. Boosting returns, risk diversification, and harvesting alternative risk premia are some of the reasons that have motivated them. Fine wines, alongside other tangible assets, have been especially impacted by this trend. Twenty years ago, they were mostly considered as consumer, or in some cases luxury goods. Nowadays, they have their own dedicated market place (*Liv-ex*, in London), where merchants and brokers, but also collectors, investors and even wine funds can enter trading orders. Paralleling this evolution, academia has begun to investigate whether fine wines are genuinely attractive from an investment standpoint.

In their probing, researchers first devoted their attention to assessing the return to wine. Since the early works of Krasker (1979) and Jaeger (1981) – who incidentally arrived at conflicting results, there has been no clear consensus on whether wines perform better or worse than equities (see Le fur & Outreville (2019) for a comprehensive literature review). Arguably, most of this debate can be explained by differences in the research design and the period under investigation. Notably, the decrease of custom duties coupled with the willingness to discover the universe of fine wines has led to an unprecedented increase in Chinese demand since 2005 (Masset et al. (2016). This largely contributed to the price upsurge observed between 2006 and 2011. All in all, it seems reasonable to infer from existing literature that the yield to an investment in wine can be considerable in the short-term, but over the long-run it is probably not as high as equities (Dimson et al., 2015).

When it comes to the risk of an investment in fine wines, many questions remain unanswered. Similar to other alternative investments, it is difficult to identify which risk factors affect fine wines prices.[1] Practitioners often claim that wine displays low volatility but this is not always corroborated by existing research. Masset & Weisskopf (2018) argue that this can be explained by the joint effect of stale prices and non-synchronous trading (both caused by the limited number of transactions on the wine market) that make indices used in practice excessively smooth. Equally important is the question of how to assess the effect of adding wine to a portfolio's overall risk. Several studies (see, e.g., Sanning et al. (2008), Fogarty (2010), and Masset &

[1] Several studies show that market risk is significant with a beta generally in-between 0.5 and 0.7 (see, e.g., Dimson et al., 2015), liquidity risk also seems to be significant (Masset & Weisskopf, 2018).

Henderson (2010)) arrive at the conclusion that wine is interesting from a diversification standpoint. However, this conclusion may be biased due to the low liquidity of the wine market and the non-normal distribution of wine returns. More generally, it remains to be determined what could serve as a relevant measure of risk for investors in this market.

Given the high transactions costs and the illiquidity of the wine market, it is appropriate to assume that investors have a long horizon. This is also in-line with wine fund recommendations, which suggest holding periods of several years (Masset & Weisskopf, 2015). This further implies that volatility is of little relevance for most investors on this market. Although, losing a substantial amount of money and having to wait for an extended period before recovery may become a problem for them. This paper therefore focuses on "downside risk", i.e. exposure to extreme outcomes that typically have a low probability of occurrence but whose magnitude might be substantial. We consider several complementary risk metrics. First, we use measures based on drawdowns (which are cumulative negative returns) and in particular the Maximum Drawdown (MDD). This is a reference risk metric in the alternative investment and fund management industry, which looks at the worst case scenario over the long-term. We then examine Value-at-Risk (VaR) and Expected Shortfall (ES), which consider returns to determine the loss one could suffer over a certain period of time. These measures are thereby geared towards the nearer-term in comparison to MDD, and account for very negative outcomes, not just the worst one. Wine is a tangible and fundamentally alternative asset. We therefore analyze its risk both individually and from a portfolio perspective by contrasting it with appropriate benchmarks (real-estate, gold, commodities) and not only stocks and bonds. In this respect, the present study complements Bouri (2013) and Bouri et al. (2018) which compare the performance of wine with energy commodities (oil), gold and housing, respectively. In this context, wine would appear as an attractive investment if its extreme risk is limited as compared to these benchmark assets, and if it contributes to reduce the extreme risk of a portfolio. We consider a long sample period, from 1997 to 2020 for this study, and use the *Liv-ex* which is considered a reference index on the wine market.

There are a few papers that relate to the present study. Notably, Maurer et al. (2020) utilize time-varying copulas to examine the relation between wines and equities. Their framework can account for non-normality, but they only consider a short horizon (daily data over a period of seven years) and their methodology is not necessarily robust towards illiquidity. Bouri and Roubaud (2016) devote particular attention to periods of market turmoil and check whether wine can be considered as a hedge or safe haven asset. The methodology used (DCC GARCH) is

however sensitive to illiquidity and non-normality. Moreover, they do not explicitly investigate the extreme risk factors inherent to wine investments. Ben Ameur & Le Fur (2020) examine volatility transmission among several asset classes, notably wine, art and (residential) real-estate. They show that the wine market is impacted by all other markets, but only in the long-term.

Our paper contributes to the existing literature along several dimensions. First, we extend and refine the analysis of Masset & Weisskopf (2018), who show that the low liquidity of the wine market may result in artificially smooth indices. While Masset & Weisskopf (2018) intuitively estimated the level of smoothing induced by illiquidity, we follow a structured approach based on the smoothing index of Getmansky et al. (2004), then use Geltner's approach to calculate the unsmoothed returns. Second, we show that wine, studied in isolation, has a lower MDD than real-estate and commodities, a similar level to equities as well as gold, and higher than bonds. More compelling is the fact that diversifying a portfolio in wine helps reduce both its MDD and the duration of its drawdown periods. This is due to the nature of fine wine and the various factors affecting its prices,[2] many of which are rather unique and distinctive from other assets. These lead to idiosyncratic bullish and bearish trends that are likely to be reinforced by herding behaviors (Aytaç et al. (2018)). Third, VaR and ES show that the attractive features of wine from a downside risk potential perspective are also evident when observing extreme returns over short periods of time. Thus, wine may not only help reduce the probability of experiencing dramatic cumulative negative returns over a certain time frame, but also of losing substantial amounts of money in one single period. Also, wine offers a potential for reducing downside risk that is very similar to gold. Since these two assets are sensitive to different variables, it seems appropriate to combine them in a portfolio. Fourth, complementary analyses provide additional support to our results. In particular, we show that the complexity of the wine market and the coexistence of distinct customer segments (including investors and collectors) represent an advantage. This can be exploited to further reduce the extreme risk of a portfolio, notably by diversifying into wines from Burgundy and Italy. Additionally, our baseline analysis assumes that portfolios are constantly rebalanced, which is unrealistic in the context of an illiquid asset like wine. Even when considering buy & hold portfolios, wine retains its attractive features in terms of downside risk management and its synergy with gold is even strengthened. Finally, we also compute minimum risk and optimized portfolios. The results show that contrary to most assets, wine retains a positive allocation of close to 10% in all estimated portfolios. In fact, only bonds systematically

[2] Existing literature documents the following variables as having a significant influence on wine prices: weather conditions, expert scores, individual and collective reputation, status, economic and financial conditions (see, e.g., Storchmann (2012) and Ashenfelter et al. (2018) for an overview of existing research on these topics). See also Livat et al. (2019) for an analysis of the price dynamics of wines from various Bordeaux appellations.

have a positive allocation. Gold gets a non-zero weight only if we consider portfolios optimized on the basis of volatility and not extreme risk.

Section 2 presents our dataset and explains how returns are adjusted for illiquidity. Section 3 is devoted to the empirical analysis. In section 4, we conduct additional tests and examine minimum risk and optimized portfolios. Section 5 concludes.

2 Data and adjustment for illiquidity

In this section, we begin by presenting our dataset and descriptive statistics. We then examine whether the lack of liquidity of the wine market results in statistical problems, where other assets essentially serve as a benchmark. Finally, we explain how to adjust returns that, due to illiquidity, are artificially smooth.

2.1 Presentation of the dataset

This study examines the (extreme) risk of fine wine and contrasts it with other assets. We use the *Liv-ex* Fine Wine Investables index to track the evolution of wine prices. Bordeaux wines constitute the bulk of this index and can be considered as representative of a typical portfolio (cellar) of an investor in this market. *Liv-ex* is a world leader and global hub for wine buyers and sellers thanks to its trading platform. *Liv-ex* indices are widely regarded as reference benchmarks and also appear to be the most reliable indices for the wine market (Masset & Weisskopf, 2018). The company is located in London, a key market for trading fine wines, especially Bordeaux appellations for centuries. We therefore adopt the perspective of a U.K. investor and use indices denominated in GBP for all our analyses. We consider five benchmark asset classes and track their evolution with the following total return indices: FTSE 100 (Equities), IBBOX £ SOVEREIGNS (Bonds), FTSE EPRA Nareit UK (Real-estate), Gold Bullion LBM (Gold), and S&P GSCI (Commodities). Data has been retrieved from Thomson Reuters Datastream. The sample covers the period beginning December 1997 ending March 2020, providing a total of 268 monthly observations. The wine market has experienced impressive development over past decades, but until recently, the limited number of transactions on the *Liv-ex* trading platform made it difficult to estimate indices at a frequency higher than monthly. In fact, the wine index considered in our analysis is updated monthly.[3] The equity, bond and real-estate indices are denominated in GBP. The other indices were originally in USD and have therefore been

[3] The *Liv-ex 50* is the only index to be available on a daily basis but only since 2010. This index covers a relatively short period of time and it suffers from several issues, which affect its spectral properties (negative autocorrelation at high frequency, which reverts and becomes highly positive when lower frequency data is considered) (see Masset & Weisskopf, 2018). It is therefore not suitable for the analysis we intend to do in this paper.

converted to GBP using the exchange rate at the end of each month. In order to account for the fact that investors may have different reference currencies and invest in a broader variety of (international) assets, we run complementary analyses in which we use EUR and USD denominated assets and other wine indices (see section 4).

We compute the monthly discrete returns of the various assets as follows:

$$r_t = \frac{P_t}{P_{t-1}} - 1, \qquad [1]$$

where P_t denotes the index level at the end of month *t* and r_t is the corresponding monthly return.

Table 1. Descriptive Statistics

	Equity	Bonds	Real estate	Commodities	Gold	Wine (Original)	Wine (Geltner)
Mean	4.65%	6.10%	5.51%	-0.45%	8.31%	6.10%	6.37%
Min	-13.41%	-8.97%	-22.25%	-34.90%	-24.74%	-12.83%	-27.12%
Max	9.01%	5.48%	25.11%	30.20%	20.79%	8.95%	15.36%
Volatility	13.86%	5.94%	19.47%	27.57%	20.01%	7.60%	15.07%
Skewness	-0.67	-0.96	-0.32	-0.47	-0.04	-0.48	-0.68
Excess kurtosis	0.75	5.13	2.85	1.92	1.67	3.85	3.99
Jarque-Bera test	26.01***	332.4***	94.56***	50.71***	30.95***	529.66***	563.31***

Notes: mean and volatility are annualized. Wine (Original) and Wine (Geltner) report statistics for original and Geltner liquidity-adjusted wine returns. *, ** and *** denote statistical significance at the 90%, 95% and 99%-level respectively.

Table 1 displays descriptive statistics for the original indices as well as for the Geltner (1991) liquidity-adjusted returns to the wine index (see sections 2.2 and 2.3 for details). The sample has been marked by several periods of severe market turmoil including notably the Global Financial Crisis (GFC). This is reflected in the rather low average return of the equity and real-estate indices. Only commodities fared worse, posting on average, negative returns since 1997. The best performers are fine wines, gold, and – more surprisingly – bonds. These asset classes have certainly benefited i) the willingness of investors to protect their portfolios against potential severe market conditions, ii) the substantial amounts of liquidity available since the GFC, and iii) the decline in interest rates. Once more, fine wines and bonds emerge as the most attractive investments in terms of volatility over the last decades, whereas commodities appear to be the riskiest, coupled with gold and real-estate. Equities display an annualized volatility close to 14%, placing them in-between bonds and wines on one side along with other tangible assets on the other.

The returns to all financial and tangible assets are both negatively skewed and leptokurtic. In finance, such a combination usually implies that the assets under investigation tend to experience a majority of slightly positive returns and fewer but more pronounced negative returns. That said, high excess kurtosis may also indicate that an asset experiences plenty of close-to-zero periodical returns, typical of an illiquid asset. This is indeed the case of wine. The *Liv-ex* index displays an excess kurtosis close to 4, with plenty of negligible returns and very few large returns – a majority of which are positive. Contrarily, the FTSE's, excess kurtosis is closer to 0, although it has numerous, large and mostly negative returns. From a statistical standpoint, non-zero skewness and excess kurtosis suggest that returns are not normally distributed, which is confirmed by both univariate (Jarque-Bera) and multivariate (Mardia) tests.[4] The rejection of the normality assumption provides supplementary motivation to look at risk measures other than volatility – which, by definition, is very sensitive to this issue.

2.2 Illiquidity and smoothed returns

Evidently, analyzing risk – especially extreme risk – of any asset requires accurate values to track its evolution, even though this condition is not always satisfied. Namely, if an asset suffers from a lack of liquidity and the methodology used to calculate the index does not take this into account, its dynamics will be biased. All asset classes considered in this study, except wine, are actively traded on public markets and thus liquidity should not be an issue. Fine wines, however, are less frequently traded and, while the *Liv-ex* wine indices are considered as the industry benchmark, are not robust to illiquidity (Masset & Weisskopf, 2018). In point of fact, these indices are estimated using a weighted average of the constituents' mid-prices (defined as the average between bid and ask prices). If over a certain time interval there is no transaction or if no new bid or ask price is recorded, then the previous period's value is used. This naturally induces a smoothing effect, which leads to an artificially low volatility and a positive autocorrelation (Masset & Weisskopf, 2018).

In Panel A of Table 2, we display the first three autocorrelation coefficients for each asset. As discernable, all three autocorrelation coefficients are significant at the 99%-level for wine. In particular the first order autocorrelation coefficient is equal to 0.6043, making it statistically and highly economically significant. This is confirmed by the results from the Ljung-Box test (Lo, 2001) which strongly rejects (at the 99%-level) the null that the time-series of wine returns is not

[4] Mardia skewness and kurtosis are respectively equal to 10.93 and 80.66, thereby leading to a clear rejection of the hypothesis of multivariate normality.

autocorrelated.[5] Interestingly, commodities and real-estate also display a statistically significant first-order autocorrelation coefficient, although far less pronounced than for wine. This observation illustrates that a non-zero autocorrelation does not necessarily imply an illiquidity issue but may be due to the economic functioning of a market (e.g., seasonality, trends, reversal and/or momentum effects).

Table 2. Autocorrelation and Smoothing index

Panel A. Autocorrelation							
Lag	**Equity**	**Bonds**	**Real-estate**	**Commodities**	**Gold**	**Wine (Original)**	**Wine (Geltner)**
1	0.0346	0.0093	0.1497***	0.1744***	- 0.1016	0.6043***	0.0072
2	0.0352	- 0.0137	0.0116	0.0741	- 0.0075	0.3673***	0.0168
3	0.0002	- 0.0379	0.0847	0.0436	0.0284	0.2440***	0.0352
Panel B. Smoothing index							
	Equity	**Bonds**	**Real-estate**	**Commodities**	**Gold**	**Wine (Original)**	**Wine (Geltner)**
$\hat{\theta}_0$	0.9667	0.8708	0.8404	0.7800	1.0785	0.5471***	0.9785
$\hat{\theta}_1$	0.0516	0.0717	0.1536**	0.1545**	- 0.1036	0.3199***	0.0215
$\hat{\theta}_2$	- 0.0183	0.0574	0.0058	0.0653	0.0250	0.1329***	0.0000
Smoothing index	0.9376	0.7667	0.7300	0.6366	1.1746	0.4193	0.9579

Notes. The smoothing index is computed using the R package PerformanceAnalytics (Peterson and Carl, 2020). *, ** and *** denote statistical significance at the 90%, 95% and 99%-level respectively. For $\hat{\theta}_0$, $\hat{\theta}_1$ and $\hat{\theta}_2$, significance is assessed on the basis of a z-test, which tests if the coefficient are different from one ($\hat{\theta}_0$) and from zero ($\hat{\theta}_1$ and $\hat{\theta}_2$) respectively.

Getmansky et al. (2004) propose the computation of a so-called smoothing index to determine whether a times-series of returns is impacted by a lack of liquidity, ergo it needs to be corrected. This method assumes that the observed smoothed return in period t (r_t) is a weighted average of the true returns (r^*_{t-j}, $j = 0, \ldots, k$) over the most recent k + 1 periods, including the current period:

$$r_t = \theta_0 r_t^* + \theta_1 r_{t-1}^* + \cdots + \theta_k r_{t-k}^* \quad [2]$$

$$1 = \theta_0 + \theta_1 + \cdots + \theta_k \quad [3]$$

Under the smoothing mechanism [2], the "information generated at date t may not be fully impounded into prices until several periods later" (Getmansky et al., 2004: p. 547). The constraint [3] implies that the information driving the true returns of a given asset can potentially be fully

[5] We find similar results for up to 12 lags (i.e., one year of data). Detailed results are available upon request.

reflected in observed smoothed returns.[6] The smoothing index is then computed as the sum of the squared $\hat{\theta}_j$ fit coefficients. The intuition is simple: if a time-series of returns does not suffer from smoothing and illiquidity, then θ_0 should be close to 1 and all other coefficients ($\theta_j, j > 0$) should be close to 0, thereby resulting in a smoothing index that is close to 1. If illiquidity and smoothed returns are found, the smoothing index will be lower than 1. Model [2]-[3] can be estimated via a MA(k) process using maximum likelihood.

We report the estimation results of the smoothing index in Panel B of Table 2. According to the AIC information criterion, setting the number of lags k of the MA process equal to 2 is appropriate. In order to confirm an absence of smoothing, $\hat{\theta}_0$ should not be statistically different from one, and $\hat{\theta}_1$ and $\hat{\theta}_2$ should not be statistically different from zero. We perform a z-test to assess the significance of the $\hat{\theta}_1$ and $\hat{\theta}_2$ coefficients and then, following Chan et al. (2005), we use a bootstrap procedure to check if $\hat{\theta}_0$ is different from one. Under the null hypothesis of no smoothing, the z-statistic is asymptotically normal. For stocks, $\hat{\theta}_0$ is almost equal to 1.00, while $\hat{\theta}_1$ and $\hat{\theta}_2$ are close to zero. This is reflected in the smoothing index which is close to 1.00,[7] showing that stocks react very quickly to new information. The same observation, albeit somewhat nuanced, can be made for bonds, real-estate and commodities. These markets are marked by a certain latency in the information/variables that drive them (for example, interest rates, which drive the performance of bonds, follow rather smooth cycles) and therefore have a lower smoothing index than stocks. Wine is the only asset whose coefficients are all significantly different from what is expected under the null hypothesis. It is by far the slowest asset to incorporate new information: 32% of the observed returns in month t can be traced back to the real unobserved return in month t-1 with another 13% to month t-2. This translates into a smoothing index of only 0.42, which univocally proves a smoothing issue and thus call for the use of filtered returns in the empirical analysis.

2.3 Liquidity-adjusted returns

In order to unsmooth returns, we resort to the method proposed by Geltner (1993). As discussed above, even in the absence of an illiquidity issue, the autocorrelation may still slightly deviate from zero. It is thus important to determine the "natural level" of autocorrelation for

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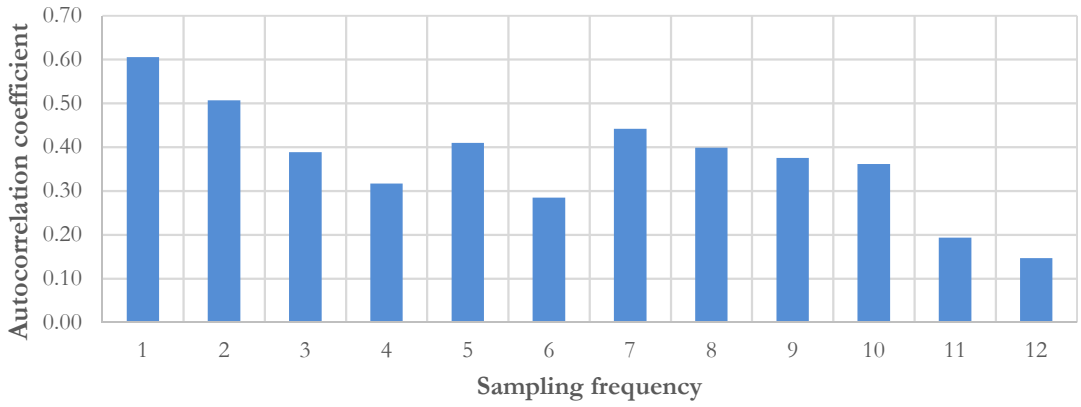
[6] In contrast to Getmansky et al. (2004), we do not impose the additional constraint that the MA coefficients $\theta_j \in [0, 1]$ so as to obtain an indication of some sort of misspecification, i.e., negative theta coefficients.

[7] Estimates falling outside the unit interval $[0, 1]$ indicate a possible misspecification (Getmansky et al., 2004). This is the case for stocks and gold. In order to ensure that these results are not driven by the number of lags used, we have also estimated the model with $k = 1, .., 7$ and obtained consistent results with several coefficients that are either negative or exceed 1.

wine, so that the original smoothed returns are not overcorrected, whereby the result would be excessively volatile unsmoothed returns. Masset & Weisskopf (2018) argue that data sampled at a lower frequency should be less sensitive to illiquidity. Figure 1 shows that the first-order autocorrelation coefficient of the wine index drops from 0.61 to just 0.15 when annual - as opposed to monthly data is used. This is consistent with the argument of Masset & Weisskopf (2018) and gives some preliminary indications about the natural level of autocorrelation of wine returns. In order to enhance the analysis, we use similar data as in Masset & Weisskopf (2018) (118'298 price observations) and then calculate the autocorrelation, exclusively using data from the exact same wine (i.e., same winery and same vintage) traded at the same location in months M-2, M-1 and M (in order to calculate the returns in months M-1 and M).[8] We obtain a first-order autocorrelation which is significantly negative at -0.34 (based on 2'953 returns). The second order autocorrelation is equal to -0.01 (523 returns) and is not significant. This result, surprising at first glance, is consistent with McManus et al. (2013). The authors depict a tendency of wine prices to exhibit a reversal after very large price changes. Given the emotional nature of this asset, such behavior is to be expected, especially at auctions when collectors compete to buy the same lot of an exceptional wine.[9] In any case, this analysis suggests that there is no reason to not fully unsmooth wine returns, i.e. to correct them such that the autocorrelation of unsmoothed wine returns is close to zero.

[8] This dataset contains auction hammer prices for 72 wineries from Bordeaux and 37 vintages (1975 to 2011) over the period 01/2005 to 12/2014. It covers all major auction houses and location in Europe, USA and Asia.
[9] Bottle condition may also play a role. That is, a wine with a damaged label or cork will sell at a discount, which will be corrected at the next auction if a bottle of the same wine but in pristine condition is sold.

Figure 1. First-order autocorrelation of the wine index at different sampling frequencies



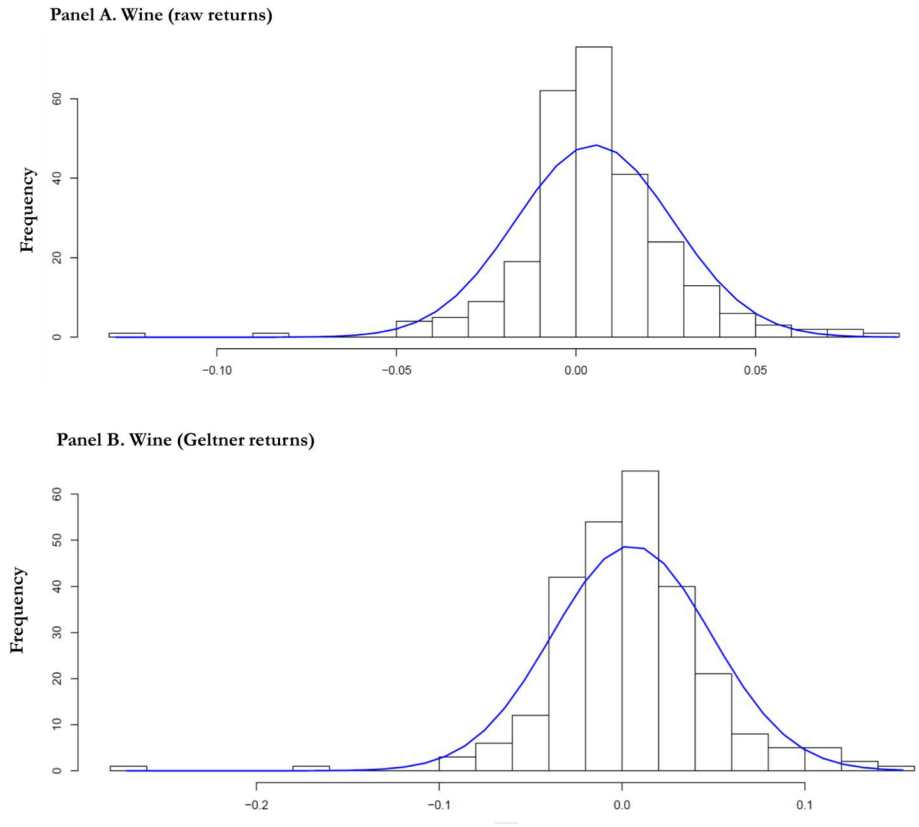
Note: the horizontal axis refers to the interval (in months) between two observations used to compute the returns (1 = monthly, 3 = quarterly, 6 = bi-annual, 12 = annual).

The method of Geltner (1993) to unsmooth returns was originally developed for analyzing real-estate indices. It has since also been applied to correct for illiquidity-induced autocorrelation of other asset classes. For instance, Brooks & Kat (2002) and Masset & Weisskopf (2018) employ it in the context of hedge funds and fine wines. The adjusted return series is calculated as:

$$r_t^{uns} = \frac{r_t - (r_{t-1} \times \rho_1)}{1 - \rho_1}, \qquad [4]$$

where r_t and r_t^{uns} stand for original (smoothed) and adjusted (unsmoothed) returns to wine at time *t*. The parameter ρ_1 controls for the part of the first-order autocorrelation of the smoothed wine returns that is due to illiquidity. As explained above, we set ρ_1 equal to 0.6043 (the first-order autocorrelation of the original wine returns series as reported in Panel A of Table 2).

Figure 2. Histograms of the original and Geltner liquidity-adjusted wine return series



Note: the histograms include the curve from a normal distribution.

In order to facilitate comparison of statistical properties for the Geltner liquidity-adjusted returns series with the original series, we report its descriptive statistics in Table 1 (column labelled "Wine (Geltner)") and plot their respective histograms in Figure 1. As can be noticed, the main difference between the two series lies in their volatility, with the liquidity-adjusted series exhibiting a much wider distribution of returns. The column label "Wine (Geltner)" in Table 2 further shows that the Geltner liquidity-adjusted series displays no statistically significant autocorrelation (Panel A) as well as a smoothing index that is very close to 1, thereby demonstrating that the illiquidity/smoothing issues has been efficiently solved. Therefore, we use the unsmoothed wine returns series r_t^{uns} in the subsequent empirical analyses.

3 Downside risk analysis

As discussed above, all six assets under consideration exhibit non-normal returns. Therefore, it is necessary to use measures which account for asymmetry and fat tails in the distribution of returns to properly assess their risk. In other words, the probability that an investor might lose a

lot of money should be examined. In order to provide a comprehensive analysis of the impact of including tangible assets into a portfolio on its downside risk, we look at several complementary measures including Maximum Drawdown (MDD), Value-at-Risk (VaR) and Expected Shortfall (ES).

3.1 Maximum Drawdown analysis

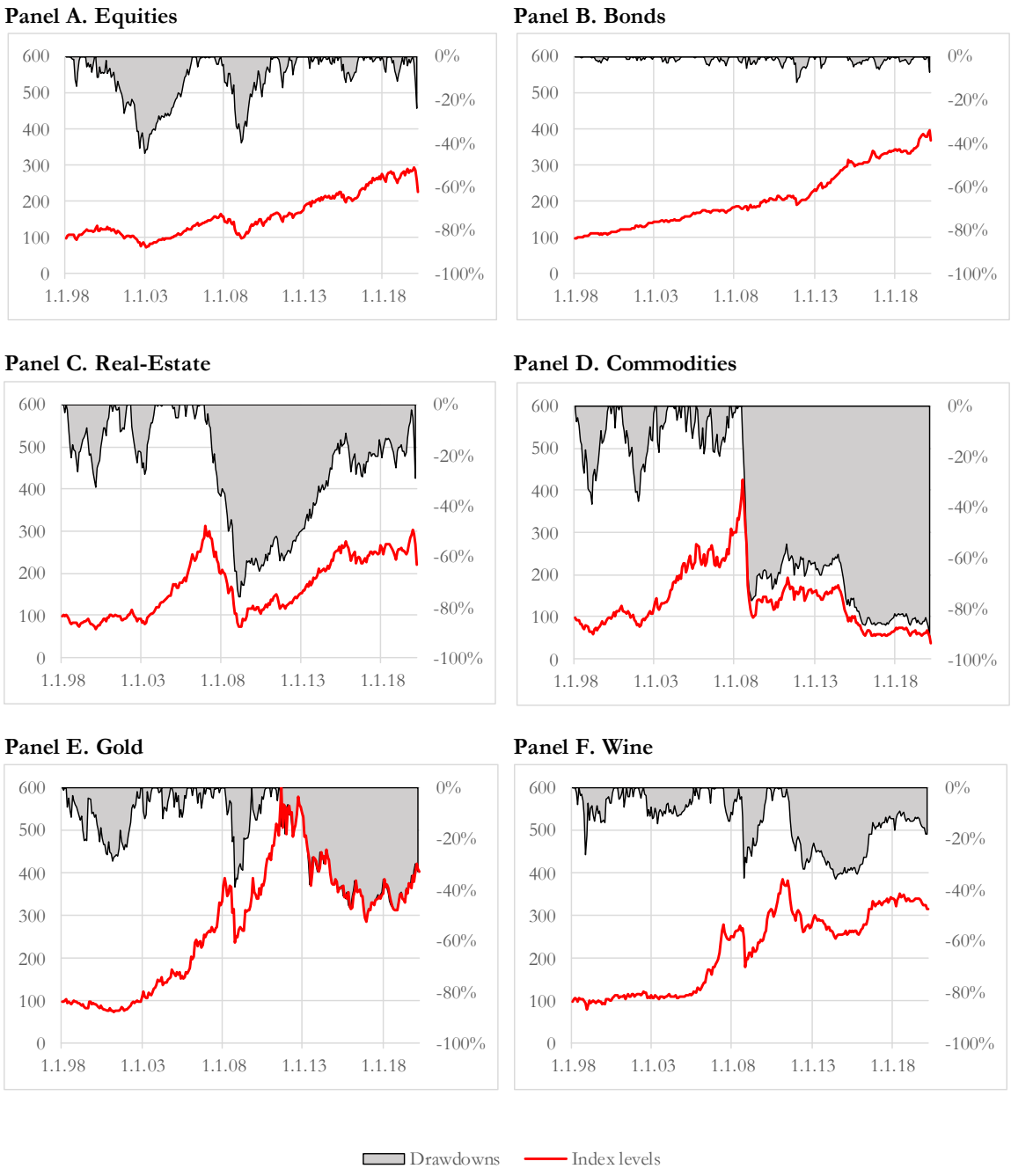
A drawdown captures the loss of an asset or portfolio from its previous peak. It ranges between -100% (total loss) and 0% (if the asset currently trades at its peak). The maximum drawdown (MDD) is defined as the most negative drawdown recorded over a certain period of time. This measure is widely used in practice and is especially relevant in the context of a thinly traded asset such as wine that requires a long holding period. Its main drawback is that it focuses on the single largest loss and it is therefore sensitive to the sample period considered. In order to mitigate this issue, we consider MDD over the period and further analyze individual drawdowns prior to running robustness tests (see section 4).

The drawdowns of all six indices are plotted in Figure 3. Panel (A) reports results for the FTSE 100 index. Its MDD equals –44.41% at the end of January 2003 after a period of decline which began in January 2000. Panels (B) to (F) report the drawdowns for all other indices. Visually, the difference between bonds (panel B) and other asset classes is striking. Bonds have continuously and steadily increased over the sample period experiencing only brief and moderate

corrections. This is reflected in their MDD, which does not exceed -12%. Real-estate (C) and commodities (D) experienced severe corrections during the GFC, never reattaining their pre-crisis levels. However, it should be noted that real-estate managed to recoup a large chunk of their losses, whereas commodities further declined in value over the period 2009-2020. Even if one disregards the GFC, both real-estate and commodities frequently suffer large drawdowns.

Panels E and F display key similarities in terms of price evolution and drawdowns. Both gold and fine wines strongly appreciated until 2011, after which they declined in value. Fine wines entered

Figure 3. Index levels and drawdowns



Note: The index levels are reported on the left axis and the drawdowns on the right axis.

into a down market phase in March 2011 followed by gold six months later. Generally, drawdowns and MDD are less pronounced for wine than for gold.

Table 3. Maximum Drawdown analysis

Panel A: individual assets				
Asset class	**MDD**	**Average Drawdown**	**Deviation Drawdown**	**Time-under-water (months)**
Equity	- 44.41%	7.31%	4.35%	74
Bonds	- 11.68%	2.78%	1.30%	16
Real estate	- 75.84%	16.48%	5.41%	160
Commodities	- 91.18%	17.32%	4.68%	142
Gold	- 52.11%	11.87%	6.83%	104
Wine	- 35.82%	10.44%	3.71%	110
Panel B: portfolios				
	MDD	**Average Drawdown**	**Deviation Drawdown**	**Time-under-water (months)**
PF Benchmark	- 23.20%	4.82%	2.88%	45
PF C	- 27.46%	5.26%	3.37%	63
PF G	- 18.22%	4.19%	2.45%	35
PF W	- 19.22%	3.44%	2.52%	40
PF CG	- 22.85%	4.87%	2.92%	40
PF CW	- 22.07%	4.16%	2.93%	40
PF GW	- 18.25%	3.66%	2.39%	35
PF CGW	- 21.37%	4.32%	2.73%	38

Note: this table reports statistics for the worst drawdown period including MDD (defined as the maximum drawdown), average and deviation drawdown (defined respectively as the average and standard deviation of the monthly drawdowns). PF benchmark contains 50% invested in equity, 35% in bonds and 15% in real-estate. PF C, PF G and PF W contain 20% invested in commodities (C), gold (G) and wine (W) respectively. PF CG, CW and GW contain 10% invested in C & G, in C & W and in G & W respectively. PF CGW contains 6.67% invested in C, G and W. In portfolios PF C to CGW, the weight of equity, bonds and real-estate is reduced by 20% as compared to the benchmark portfolio to ensure that the sum of the weights remains equal to 100%.

Table 3 presents summary statistics regarding the average and standard deviation of the drawdowns as well as the "Time-under-water" for the worst drawdown period, complementing the preceding largely visual analysis. Time-under-water quantifies the period during which an asset trades below its previous peak until it reclaims a similar level. It gives an indication as to how long it may take for an investment to fully recover from an extreme loss. Panel A considers individual assets. Bonds, again, undoubtedly emerge as the only asset class with lower downside risk than equities (FTSE). Tangible assets are characterized by cycles which can be protracted (Time-under-water) and severe (MDD). Stocks, bonds and fine wines tend to drop quickly, thus experiencing a short correction period, although their recovery often takes longer than the other three asset classes. We also look at the second and third worst MDD for each asset.[10] Fine wines have experienced three drawdown periods of fairly similar severities (MDD between -25% and -35%) but of variable duration (from 26 to 110 months). Overall, fine wines did not experience

[10] To save space, results are not reported here but are available upon request.

such acute correction phases as the other tangible assets. Nevertheless, in Figure 3, one can observe that its positive performance over the complete sample period is mostly explained by two brief albeit significant periods of increase between 2005 and 2007, followed by the period between 2010 and 2011. These two periods were characterized by the arrival of new buyers (investors and Asian customers) and the release of several outstanding vintages (2005 – sold in 2006, 2009 and 2010 – sold in 2010 and 2011 respectively). This observation may at first glance appear troublesome as it suggests the performance of an investment in wine is not as good as some brokers and wine funds would argue (it is however in line with Dimson et al. (2015)'s results), except for short periods of strong increase. Notwithstanding, it also delineates one potential advantage of wine: the dynamics of this market to a large extent depend on factors and events that are inherent to wine itself. From an extreme risk diversification standpoint, this observation is encouraging.

Deepening the analysis, we adopt a portfolio approach by considering a series of representative portfolios. The results are reported in panel B of Table 3. Most investors start building their portfolios by investing in equity, bonds and real-estate, before considering the inclusion of alternative assets such as gold, commodities, or wine – primarily for diversification purposes. As such, we begin with a typical benchmark portfolio comprising 50% equities, 35% bonds, and 15% in real-estate securities. It should be highlighted that the MDD of the benchmark portfolio is far less pronounced than both equity and real-estate, but higher than bonds. Indeed, adding bonds to a pure equity portfolio appears very effective from a diversification standpoint, although further diversifying the portfolio into real-estate does not contribute in the reduction of its downside risk – in fact, it increases it. This is due to the low (and sometimes even negative) correlation between equities and bonds, whereas (listed) real-estate displays high correlation with equities. Following this, we modify the benchmark portfolio composition by adding 20% of the various alternative tangible assets, whilst proportionally reducing the weights allocated to equity, bonds and real-estate. The first three portfolios (denoted PF C, G, and W in Table 3) contain 20% invested in commodities (C), gold (G), and wine (W), respectively. The three following portfolios (CG, CW, and GW) each have 10% invested in commodities & gold, commodities & wine, and gold & wine. The final portfolio (GCW) has 6.67% invested in all of the three alternative tangible assets. Every portfolio is assumed to be rebalanced on a monthly basis.[11] Adding commodities to the benchmark portfolio does not allow for a reduction in MDD or a shortening of time-under-water. The effect of diversifying a

[11] It would of course be more realistic to consider portfolios that are rebalanced less frequently given the limited liquidity of the wine market. We investigate this issue as a robustness test, see section 5.

portfolio via gold and wine is similar, but more effective. Interestingly, including either 20% or 10% of gold or wine leads to near identical results.[12] Even when mixed with gold and wine, commodities seem to present little interest from a downside risk management perspective. Overall, our results indicate that diversification in wine and/or gold permits the reduction of MDD and time-under-water. These two assets impact downside risk in a way that is quite similar to bonds.

Table 4. Probability that two assets experience a drawdown at the same time

Panel A: all drawdowns

	[1] Equity	[2] Bonds	[3] Real-estate	[4] Commodities	[5] Gold	[6] Wine
[a] Equity	100%	62%	88%	88%	88%	89%
[b] Bonds	80%	100%	90%	93%	88%	86%
[c] Real-estate	78%	62%	100%	92%	89%	88%
[d] Commodities	77%	62%	90%	100%	89%	87%
[e] Gold	79%	61%	89%	91%	100%	90%
[f] Wine	81%	60%	89%	90%	90%	100%

Panel B: drawdowns of -20% or worse

	[1] Equity	[2] Bonds	[3] Real-estate	[4] Commodities	[5] Gold	[6] Wine
[a] Equity	100%	0%	35%	43%	25%	18%
[b] Bonds	N/A	N/A	N/A	N/A	N/A	N/A
[c] Real-estate	14%	0%	100%	82%	43%	41%
[d] Commodities	14%	0%	64%	100%	61%	41%
[e] Gold	11%	0%	47%	87%	100%	40%
[f] Wine	14%	0%	79%	100%	70%	100%

Note: this table reads as follows: it reports in panel A the probability that the asset on the vertical axis [number] is experiencing a drawdown if the asset on the horizontal axis [letter] is experiencing a drawdown. Panel B reports the same information but for drawdowns of at least -20%. Note that bonds have never experienced such a drawdown and therefore the probability along the corresponding lines are reported as "N/A".

Table 4 reports the probability that two assets experience a drawdown at the same time. Examining overlaps amongst the drawdowns of the various assets allows for greater precision when investigating sources of extreme risk diversification. Panel A considers all drawdowns, whereas panel B focuses on economically significant drawdowns of at least -20%. Panel A shows that stocks and tangible assets tend to experience drawdowns simultaneously. Bonds, on the other hand, often (about 40% of the time) moves in the opposite direction of other asset classes.

[12] In unreported analyses (available upon request), we also examined the effect of adding more than 20% into these two assets and observed further reductions in downside risk.

This very behavior, in combination with a limited MDD, explains why including bonds in a portfolio enables a substantial reduction of its downside risk. When looking at Panel B, it must first be observed that bonds have never fallen by more than -20%. Real-estate and commodities fall sharply (-20% or more) approximately 40% of the time when equities are down by a similar percentage, thereby offering some limited diversification benefits. Gold fares better as it experiences drops of -20% or more 25% of the time. Wine stands out as the most interesting tangible asset since the probability that it experiences a drawdown of -20% or worse when the FTSE falls by a similar amount is equal to 18%.

Overall, the results at this stage suggest that bonds are the most resilient asset class, as they are rarely in drawdown when the other assets are. The approach of dedicating a small proportion (typically 5% to 10%) of gold and wine to a portfolio also seems relevant. It should also be underscored that the resilience of these last two assets is mostly felt when other markets decline by 20% or more. Wine appears particularly interesting as its MDD is limited and its periods of decline rarely overlaps with important drawdowns of the FTSE. Accordingly, including gold and wine in a portfolio with stocks and bonds might be useful to dampen extreme loss events. In contrast, the results cast doubt on the attractiveness of including real estate and commodity assets in a portfolio in order to lower its extreme risk of loss.

3.2 Extensions to other risk measures

As mentioned, MDD is solely based on the worst-case event and is therefore sensitive to the sample period considered. Consequently, risk management or portfolio allocation decisions motivated purely on the basis of MDD may be too conservative. In this section, we remedy this by completing our analysis through employing Value-at-Risk (VaR), Expected Shortfall (ES) and Conditional-Drawdown-at-Risk (CDaR). VaR estimates the percentage loss an investment might experience given a probability α of being exceeded. It corresponds to α-quantile of the investment return distribution. ES (also known as Conditional VaR) shows the expected loss given that the loss exceeds VaR. By definition, ES is larger than or equal to VaR for a given confidence level (Roncalli, 2020). Thus it provides a more prudent picture of tail risk than VaR. Moreover, unlike VaR, ES is a coherent risk measure (Artzner et al. (1999)). CDaR is conceptually closely related to ES but is based on the drawdowns of an investment as opposed to its returns (Chekhlov et al. (2003)). Namely, it reports the expected drawdown if the drawdown exceeds a certain threshold. CDaR retains the intuitive appeal of MDD (which is widely used in practice because it assesses risk from a perspective that is relevant to most investors), while enhancing it by not only taking into account but also other adverse yet less dramatic events.

Table 5. Risk metrics for individual assets and portfolios

Panel A: individual assets				
	99%-Value-at-Risk (VaR)	97.5%-Expected Shortfall (ES)	Conditional Drawdown at Risk (CDaR)	
			99%	97.50%
Equity	10.98%	11.02%	41.68%	32.21%
Bonds	5.32%	5.17%	8.81%	6.40%
Real-estate	16.86%	15.71%	67.61%	55.26%
Commodities	18.90%	22.26%	76.49%	54.45%
Gold	13.58%	14.69%	47.93%	41.65%
Wine	8.68%	12.18%	35.75%	35.65%
Panel B: portfolios				
	99%-Value-at-Risk (VaR)	97.5%-Expected Shortfall (ES)	Conditional Drawdown at Risk (CDaR)	
			99%	97.50%
PF Benchmark	6.51%	7.33%	24.59%	14.81%
PF C	7.80%	9.01%	23.10%	11.10%
PF G	8.02%	7.41%	16.05%	10.37%
PF W	6.26%	8.46%	19.29%	13.82%
PF CG	7.06%	7.73%	19.01%	9.97%
PF CW	6.62%	9.40%	21.03%	12.64%
PF GW	6.45%	8.32%	16.52%	10.42%
PF GCW	6.77%	7.04%	18.48%	10.85%

Note: PF benchmark contains 50% invested in equity, 35% in bonds and 15% in real-estate. PF C, PF G and PF W contain 20% invested in commodities (C), gold (G) and wine (W) respectively. PF CG, CW and GW contain 10% invested in C & G, in C & W and in G & W respectively. PF CGW contains 6.67% invested in C, G and W. In portfolios PF C to CGW, the weight of equity, bonds and real-estate is reduced by 20% as compared to the benchmark portfolio to ensure that the sum of the weights remains equal to 100%.

In Table 5, we report the 99%-VaR and 97.5%-ES. The confidence level selections are motivated by the recent decision of the Basel Committee to replace the 99% VaR with the 97.5% ES (BCBS, 2019). As we are not specifically concerned about banking regulation, we report both risk measures in addition to the 97.5% and 99%-CDaR. We use the historical approach to estimate the various risk measures because it is non-parametric and thereby less sensitive to non-normality. Panel A of Table 5 reports the results for individual assets. Bonds display the lowest VaR, ES and CDaR, by far. Fine wines obtain the second rank - just ahead of equities when 99%-VaR and 99%-CDaR are considered. The 97.5%-ES and 97.5%-CDaR indicate that equities slightly outperform wine. Gold displays a higher downside risk than these three assets, nevertheless remaining safer than real-estate and commodities. Naturally, the CDaR always paints

a gloomier picture than the VaR and ES. Indeed, CDaR looks at cumulated negative returns, whereas the other two measures focus on individual extreme returns. All in all, it seems reasonable to conclude that bonds have the lowest downside risk. Equities rank ahead of all tangible assets except for wine. Real-estate and, more surprisingly, gold appear substantially riskier than equities. Ultimately, commodities constitute the riskiest asset class.

As seen in section 3.1, the fact that certain tangible assets appear rather risky from a univariate dimension does not necessarily imply that they cannot contribute in reducing the downside risk of a portfolio. Panel B of Table 5 accordingly enhances the analysis by considering a series of portfolios similar to the ones studied in Table 3. Id est, we start with a benchmark portfolio comprised of 50% equities, 35% bonds, and 15% real-estate. We then diversify it by investing in commodities and/or gold and/or wine to compare their respective levels of risk. From a VaR perspective, wine displays the strongest ability to reduce the downside risk of a portfolio. When turning to ES, gold takes the lead although wine does remain more attractive than commodities. The results for CDaR are generally consistent with those already reported, with gold and wine exhibiting the largest potential downside risk reduction, but they also differ on some aspects. In particular, the benchmark portfolio is much riskier from this perspective and adding any of the alternative tangible assets (including commodities), leads to a reduction of downside risk. Overall, the results agree with those of the previous section and demonstrate the potential of diversifying into tangible assets - particularly gold and wine to improve downside risk management.

4 Complementary analyses and portfolio implications

In this section, we begin by conducting several complementary analyses to ensure that our results are as general as possible and robust towards changes in the research design. We then assess the proportion of a minimum risk and optimized portfolio that should be allocated to wine and other tangible assets.

4.1 Robustness tests

Wine investments have unique features that need to be considered in order to properly assess their impact upon a portfolios' risk. Firstly, contrary to gold and commodities – but similar to real-estate, the wine market is characterized by the coexistence of several segments, with distinctive characteristics in terms of risk and return. Moreover, most wines are produced in the Eurozone but are subsequently traded in countries where GBP or USD serve as the reference currencies. Exchange rates might therefore play a role in the dynamics of wine prices and by extension on its appeal from a risk management standpoint. Lastly, as discussed in section 2, the

wine market is rather illiquid, thereby making it advisable to reduce trading frequency. As such, it appears supreme to assess the impact of investing and rebalancing decisions over specific periods of time. Table 6 reports the results of these complementary analyses. Panels A and B report MDD and ES for the various portfolios.

Table 6. MDD and Historical expected shortfall (complementary analyses)

Panel A: MDD							
	Wine index		**Subperiod and rebalancing**		**Reference currency**		**Original returns**
	Burgundy	Italy	post-GFC	Buy & Hold	EUR	USD	
PF Benchmark	-33.1%	-33.1%	-26.7%	-31.7%	-41.1%	-37.3%	-33.1%
PF C	-40.6%	-40.6%	-35.1%	-43.2%	-41.5%	-41.5%	-40.6%
PF G	-28.9%	-28.9%	-24.0%	-27.2%	-29.2%	-27.8%	-28.9%
PF W	-24.0%	-24.1%	-23.7%	-28.3%	-39.6%	-37.0%	-28.5%
PF CG	-34.9%	-34.9%	-29.7%	-33.8%	-35.5%	-34.7%	-34.9%
PF CW	-32.7%	-32.7%	-28.8%	-33.8%	-39.9%	-38.5%	-34.7%
PF GW	-26.4%	-26.5%	-23.1%	-25.8%	-33.9%	-32.5%	-28.7%
PF GCW	-31.4%	-31.4%	-27.2%	-31.1%	-36.5%	-35.1%	-32.8%
Panel B: ES							
	Wine index		**Subperiod and rebalancing**		**Reference currency**		**Original returns**
	Burgundy	Italy	post-GFC	Buy & Hold	EUR	USD	
PF Benchmark	-8.51%	-8.51%	-7.40%	-7.34%	-9.68%	-8.28%	-7.92%
PF C	-10.99%	-10.99%	-10.00%	-9.35%	-9.87%	-9.52%	-9.77%
PF G	-8.36%	-8.36%	-7.76%	-8.28%	-7.91%	-7.20%	-7.42%
PF W	-6.98%	-6.92%	-6.55%	-7.49%	-9.28%	-7.90%	-6.91%
PF CG	-9.47%	-9.47%	-8.50%	-8.42%	-8.54%	-8.15%	-8.40%
PF CW	-8.90%	-8.94%	-8.09%	-8.00%	-9.44%	-8.54%	-8.14%
PF GW	-7.46%	-7.41%	-7.00%	-7.69%	-8.28%	-7.38%	-7.03%
PF GCW	-8.59%	-8.59%	-7.80%	-7.99%	-8.61%	-7.98%	-7.76%

Note: PF benchmark contains 50% invested in equity, 35% in bonds and 15% in real-estate. PF C, PF G and PF W contain 20% invested in commodities (C), gold (G) and wine (W) respectively. PF CG, CW and GW contain 10% invested in C & G, in C & W and in G & W respectively. PF CGW contains 6.67% invested in C, G and W. In portfolios PF C to CGW, the weight of equity, bonds and real-estate is reduced by 20% as compared to the benchmark portfolio to ensure that the sum of the weights remains equal to 100%. The sample covers a shorter period for EUR (since 01/2001), USD (since 12/1998, Burgundy and Italy (since 02/2004) due to data availability. The Post-GFC period is defined as April 2009 onwards. Historical ES at the 97.5% level.

Other wine indices: so far in this article, we have used the index with the longest series of available historical data, but it may suffer from certain biases (e.g., inappropriate methodology

used to estimate the index back in the nineties) and more importantly, basing the analysis on a single index does not display the true complexity of the wine market. Nowadays, wine from various regions are considered investment-grade, which strengthens its attractiveness from a diversification standpoint. Accordingly, we repeat the analysis using the *Liv-ex Burgundy* and *Italy* indices. These indices are only available as of 2004, which is why this analysis covers a slightly shorter period. It turns out that the use of these indices further reinforces the attractiveness of wine from a downside risk management standpoint. Strikingly, we obtain near identical results for both the *Liv-ex Burgundy* and *Italy* indices, despite their dynamics having been quite distinct since 2004. Notably, wines from Burgundy have seen their prices outpace their Italian counterparts (close to 11% versus 7% p.a.). Overall, this analysis highlights one of the most interesting specificities of wine from a downside risk perspective: there are important diversification opportunities between wine and other assets, but also within the wine market itself.

Subperiod and rebalancing: given the limited liquidity and high transaction costs in the wine market, it is unrealistic to assume that one's portfolio is rebalanced on a monthly basis. Therefore we also consider buy & hold portfolios (i.e., never rebalanced). MDD and ES results remain qualitatively similar to those previously obtained, in fact, turning out slightly more favorable for wine. These results are compelling as they suggest an investor could successfully actively manage the liquid portion of her portfolio (e.g. by rebalancing it on a quarterly or yearly basis) while maintaining a satellite composed of wine that would be rebalanced far less frequently (e.g., every five years or less). We further assess whether the results might be driven by the effect of the GFC itself by looking at the post-GFC period (April 2009 onwards). MDD and ES are less pronounced for most portfolios particularly for those containing fine wines. Thus, it seems reasonable to eliminate the notion the positive effect of wine on downside risk is not due to the period considered or the portfolio rebalancing method.

Reference currency and benchmark assets: Our analysis revolves around the perspective of an investor whose reference currency is the GBP. In practice, we could have added international assets. Moreover, this GBP-centric view neglects an important specificity of the wine market: most fine wines are produced in the Eurozone, with large parts of them subsequently traded in regions where the USD is the reference currency, whilst London remains the major marketplace where prices are quoted in GBP. It is therefore possible that the results may be impacted when one considers other currencies. Evidently, exchange rates may represent a relevant source of risk for investors on the wine market. It is therefore apposite to analyze the impact of the reference currency on the downside risk of wine as opposed to other tangible

assets. The last two columns of Table 6 report the results for a European and a US investor. These portfolios are based on European and US equity (Euro Stoxx 50 and S&P 500), bonds (Bloomberg Barclays US Treasury Index and S&P Eurozone Sovereign Bond Index) and real-estate indices (FTSE EPRA REIT U.S. and Developed Europe) denominated in EUR and USD respectively. For commodities, gold and, wine, we employ the same indices as before but expressed in EUR and USD respectively. Overall, the MDD (panel A) is more pronounced when considering portfolios in USD or EUR as compared to their GBP denominated counterparts. Nevertheless, most of the results remain similar to the original ones, with the exception of portfolios containing wine. It seems that the diversification potential in terms of MDD offered by wine is significantly lower when considering the perspective of an investor whose reference currency is either USD or EUR. Contrarily, Gold remains attractive irrespective of the reference currency considered. ES (Panel B) is generally consistent with MDD, with the two benchmark portfolios in EUR and USD displaying a more pronounced ES than the GBP portfolio. However, when alternative tangible assets are added, the USD portfolios become less risky than those in GBP, on average. This illustrates the role of the exchange rate, particularly for gold and commodities where the reference currency is the USD. Wine continues to play a positive role on the ES of both USD and EUR denominated portfolios, especially when coupled with gold. Overall the results from panels A and B are peculiar at first glance - As according to ES wine remains very attractive irrespective of the currency considered, whereas the results from the MDD analysis suggest that wine may actually offer a less significant downside risk diversification for investors whose reference currency is not GBP. These two observations can be reconciled if one takes into account the fact that ES is a measure that focuses on large losses over the short-run, whereas MDD focuses on cumulative losses and consequently has a long-term perspective. In the short term there is little correlation between the evolution of wine prices and exchange rates. However, in the long term, the evolution of wine prices is more sensitive to exchange rates, hence resulting in a relatively riskier index when the GBP is not used as the reference currency. These observations also suggest that exchange rate risk is an important dimension to take into account when analyzing the dynamics of the wine market.

Return adjustment (wine): In their paper, Masset & Weisskopf (2018) advocate for correcting wine returns such that they retain a residual first order autocorrelation of about 0.1 to 0.3. Owing to this, we redo our analyses with an unsmoothing parameter of just 0.30 instead of 0.6043. This change has a limited impact on the drawdown analysis but a more significant one on the other risk measures. We also redo the analysis using the original data to examine the implication of not adjusting the returns at all. Results are reported in Table 7. MDD of the

various portfolios remain quite similar to those obtained with adjusted returns (Panel A) but the ES declines quite substantially (Panel B). This illustrates that MDD is less sensitive to illiquidity than ES. In any case, wine looks more attractive both from a standalone investment and a portfolio perspective.

4.2 Portfolio implications

So far, we have compared the ability of tangible assets to reduce the downside risk of a portfolio by considering stereotypical allocations. This approach has the advantage of being relevant for most investors, although it gives no indication as to the maximum downside risk reduction potential offered by the various assets considered. Moreover, it neglects returns and therefore only provides a partial picture of the performance of tangible assets from a portfolio perspective. In this section, we therefore complete our analysis by estimating minimum risk portfolios, and risk-return optimized portfolios. Table 7 reports the corresponding results. We focus on ES as a downside risk measure because of its mathematical properties in the context of optimization.[13] Results based on volatility are also reported for comparison purposes.

Table 7. Minimum risk and optimized portfolios

	Equity	Bonds	Real estate	Commodities	Gold	Wine	All
Panel A. Minimum risk portfolios							
Volatility							
Opt. weights	8.76%	78.88%	0.00%	0.00%	0.00%	9.42%	100%
Volatility							1.58%
ES							
Opt. weights	0.00%	88.51%	0.00%	0.00%	0.00%	11.49%	100%
ES							5.19%
Panel B. Optimized portfolios							
Mean-volatility							
Opt. weights	0.00%	58.03%	0.00%	0.00%%	30.39%	11.58%	100%
Mean							0.57%
Volatility							2.28%
Mean-ES							
Opt. weights	0.00%	88.51%	0.00%	0.00%	0.00%	11.49%	100%
Mean							0.51%
ES							5.19%

Note: ES stands for Expected shortfall.

Panel A (minimum risk portfolios) shows that bonds are to be preferred if the goal is to minimize volatility or ES. Because of their low correlation with bonds, equities and wines are also interesting, if the objective is to minimize volatility. On the other hand, if we focus on ES, the

[13] The main issue is that the optimization problem with VaR is non convex. It becomes too complex to be solved by conventional optimization methods as it typically exhibits many local minima.

only asset that is as beneficial as bonds, is wine. This demonstrates the potential of wine when the primary concern of an investor is to manage her downside risk. Panel B (optimized portfolios) presents portfolios that are surprisingly similar to those from panel A. When considering a mean-volatility framework, bonds retain the biggest allocation, but wine and even more so gold appear interesting and consequently have substantial weights. When we focus on extreme risk, we obtain a portfolio that contains a high proportion of bonds (almost 90%) and about 10% of wine. This portfolio is identical to the minimized ES portfolio. This can be explained by the impressive performance of bonds since 2000. The decline and subsequent stabilization of interest rates at low levels have ensured low risk and high return to bonds as compared to other assets. As such, the important weight allocated to bonds is unsurprising. Still, it is interesting to point out that wine, despite mixed returns, is the only asset to find its place in optimized portfolios. This demonstrates the solid potential of this asset from a downside risk management point of view.

5 Conclusion

This article examines whether diversifying a portfolio by investing in wine helps reduce its downside risk. Several reasons justify this focus on risk and more prominently on downside risk. Firstly, wine's inherent characteristics make it an alternative asset that can at times offer attractive returns, but is potentially most interesting for its contribution to risk diversification. Moreover, it is an illiquid asset that requires a long investment horizon. As a result, short-term fluctuations of small magnitude are not necessarily relevant for investors. From a statistical point of view, wine returns like most alternative assets do not follow a normal distribution. These remarks imply that volatility is an inappropriate risk measure given this context. We therefore consider extreme risk measures that are geared towards the short-term (Value-at-Risk (VaR) and Expected Shortfall (ES), which focus on very negative periodical returns) and the long-term (Maximum Drawdown (MDD), which focuses on very negative cumulative returns over a certain time frame). Moreover, given the tangible nature of wine, it is natural to compare it to real-estate, commodities and gold - which can play a similar role.

Our results may have important implications for portfolio allocation and risk management. Wine displays the least pronounced drawdowns in comparison to other tangible assets. Only bonds have a lower downside risk. But the great advantage of wine is that its price dynamics to a large extent depend on market-specific factors. This indicates a diversification potential, translating into lower downside risk for portfolios containing wine. When considering VaR and

ES, we obtain similar results, but slightly less favourable to wine. We also look at minimum risk and optimized portfolios, and wine appears as the only asset (along with bonds) whose allocation remains positive and close to 10% in all considered settings. All things considered, our results illustrate the appeal of diversifying a portfolio through wine. Although the costs associated with such an investment may appear to be too excessive to justify this type of diversification (Nahmer, 2020). However, when one considers a long-term perspective, as in the case of this article, this argument becomes less relevant. In-line with existing literature (see, e.g., Hussain Shahzad et al., 2020), we coincidentally show that gold presents similar advantages as wine. Overall, our results suggest that combining these two assets may further enhance their contribution in terms of downside risk reduction.

Our inferences also outline one of the most attractive features of wine as compared to commodities and gold. Wine's market is more complex and heterogeneous. Our main analysis is biased towards Bordeaux, which represents the biggest segment of the fine wine market. But in recent years, other regions have gained significant market share. In particular, Burgundy and Italy are attracting increasing interest from investors and alike, who now have their own dedicated *Liv-ex* indices. The prices of wine from different regions do not often evolve in the same way. This makes it possible to further mitigate downside risk by not only investing in Bordeaux wines but also in wines from Burgundy and Italy. In the future, the secondary market for other regions might become more active (see Masset et al. (2020) for a discussion of so-called frontier wine investments), which should help to improve the potential for extreme risk diversification.

Finally, we show that the investor's reference currency is an important variable. Apart from its low liquidity, one of the key specificities of the wine market is indeed its geographic organization. A majority of fine wines come from France and more generally around Western Europe. The primary market is therefore centered in the Eurozone. Historically the UK has played and continues to play an important role in the global trade of fine wines. Indeed, the *Liv-ex Investables* index is calculated on the basis of data from the London market and is quoted in GBP. Nowadays, a large part of the demand comes from countries that use the US dollar as a reference. We therefore also look at downside risk from the perspective of an investor whose reference currency is EUR or USD. From a univariate perspective, wine turns out being riskier than in our baseline analysis, nonetheless it remains interesting from a multivariate perspective as it can help reduce a portfolio's MDD and ES. This analysis delineates the role of exchange rates on the wine market and also suggests that it might be relevant in the future to examine the effects of currencies on the dynamics and risk of wine investments.

Another avenue for future research would be to investigate alternative approaches to portfolio construction when tangible assets are included in the universe of potential investments. In this paper, we have considered portfolios with pre-assigned weights, as well as minimum risk and optimized portfolios. Another way to think about asset allocation has recently emerged, the risk budgeting/parity approach. Nowadays, it is commonly applied to a variety of portfolio allocation problems because of its practical relevance (Roncalli, 2013). Its appeal being that it looks at asset allocation in terms of risk - not capital, thus requiring less discretionary inputs. Within the context of a portfolio that includes a variety of assets, which follow cycles with distinct lengths and intensities, this approach may lead to interesting results. Likewise, were historical data available for a longer period, it would be useful to consider out-of-sample tests to validate portfolio decisions.

6 References

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