Is Wine a Good Choice for Investment?

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Abstract

We extend our understanding on the role of wine investment within a portfolio of different assets (US/UK equities, bonds, gold, and housing) by considering a rich methodology based, among others, on the mean-variance and stochastic-dominance approaches. The main findings suggest that wine is the best investment among all individual assets under study, and investors prefer to invest in with-wine portfolios than without-wine portfolios to gain higher expected utility when short sale is not allowed. However, investors are indifferent between portfolios with and without wine when short-selling is allowed. In addition, with-wine portfolios generally either dominate individual assets or are indifferent from individual assets. Interestingly, the with-wine portfolios first-order stochastically dominates housing in both

long-only and short-allowed strategies, pointing towards market inefficiency and thus the possibility for an expected arbitrage opportunity. Finally, we reveal that investors prefer the low-risk with-wine portfolios to the equal-weighted portfolio, but are indifferent between the high-risk with-wine portfolios and the naïve portfolio for both long-only and short-allowed strategies. Our findings can be used by investors in their investment processes and reveal the possibility of earning abnormal returns when wine is included in the investment.

***JEL Codes*:** C10 ; G10 ; G15.

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1. Introduction

The potential role wine investment might play in equity and bond portfolio has long attracted the attention of the financial media, investors, and scholars which are always looking for alternative investment assets uncorrelated with stocks and bonds (Kourtis et al., 2012; Bouri, 2015). Unlike conventional assets that provide dividends or interest payments, fine wines do not provide any cash-flows but are favorably taxed (Kourtis et al., 2012). However, wine physical holding requires optimum storage conditions. Interestingly, the development of the UK-based London International Vintners Exchange (Live-ex) - as the principal wine market platform - has played a significant role in making the wine investment more accessible to individual investors and in enhancing the wine market liquidity and transparency. This development has also paved the way for the industrialization of the art of investing in fine wines given that several Liv-ex indices serve as leading wine benchmarks for numerous wine

investment funds[1]. Such funds offer a cheap and simplified approach to invest in fine wines (Coffman and Nance, 2009)[2].

In addition to the financial and economic factors that affect traditional financial assets like stocks, bonds, and mutual funds, the tangibility of fine wines makes the wine investment subject to distinctive factors such as the name of the producer, weather, year of vintage, grape composition, acidity, reputation, aging, and production technology (Ali et al.; 2001; Bombrun and Summer, 2003; Hadj et al., 2008; Roma et al. 2013; Storchmann, 2012). These distinctive factors can partially explain the weak or negative correlation between fine wines and traditional financial assets and the positive effect on portfolio diversification reported in prior studies (see, among others, Sanning et al., 2008 and Fogarty, 2010; Kourtis et al., 2012; Chu, 2014; Aytaç et al. 2016). Several studies consider fine wines as a useful hedge or safe haven against equity movements due to their weak or negative correlation with traditional financial assets (Bouri, 2014, 2015). However, Fogarty and Sadler (2014) argue that the presence of fine wines in a portfolio leads to trivial diversification benefits. Dimson et al. (2015) show that wine investment return underperforms equity return and that a positive correlation exists between wine investment and equities, which can potentially hinder any diversification strategy.

In addition to those mixed empirical results on the diversification benefits of fine wine investment, most of prior studies assume that wine returns are normally distributed and thus build their findings on the first and second moments of the return distribution as in the mean/variance paradigm of Markowitz (1952). They also specify the investors' risk preference or utility functions explicitly (i.e. by assuming a quadratic utility function where investor exhibits increasing relative risk aversion). Given that fine wines return distribution is not normally distributed (see, among others, Masset and Henderson, 2010; Bouri, 2014, 2015), it emerges the importance of considering the entire return distribution rather than restricting the analysis to just the trade-off between risk and return. The fact that wine returns are possibly

[1] The later include most notably Patrimoine Grands Crus in France, Lunzer Wine Fund in British Virgin Islands, the Wine Investment Fund in Bermuda, and the Nobles Crus in Luxembourg which are well-capitalized and soundly managed by major financial houses such as Deutsche Bank and Richmond Park Capital.

[2] According to Kochard and Rittereiser (2008), the Massachusetts Institute of Technology (MIT) university endowment has invested in fine wines.

skewed and leptokurtic also suggests that investors may place utility on higher moments and that investors' utility function is not quadratic but somewhat sophisticated. In this sense, investors prefer to have a downside protection while they look for a better return.

To address this gap in the wine literature, the authors of this paper construct optimal portfolios with and without fine wines and examine their performance using a stochastic dominance (SD) approach. To the best of our knowledge, this is the first paper to apply SD-based approach to examine whether wine is a better choice in the investment for investors. We consider a wide variety of assets that include US and UK equities, bonds, gold, and house prices, while most of prior studies limit their analyses to stocks and bonds. Such an in-depth analysis would extend our existing knowledge on the role wine investment would play in portfolio choice. In particular, employing the non-parametric approach of the SD is new to the wine literature and more importantly allows us to incorporate information on the entire distribution, rather than just focusing on the first and second moments. Masset and Henderson (2010) look beyond the mean/variance paradigm and take into account for the skewness and kurtosis in their examination of the benefits of equity portfolio diversification with fine wines. However, the authors limit their analysis to a parametric method and specify investors' risk preference explicitly. Interestingly, the SD can analyze any distribution without any restriction and go beyond mean, variance, skewness, and kurtosis to incorporate information of all moments in the distribution. It requires no specific assumption regarding the specific form of investor utility function and employs some general restrictions such as non-satiation and risk aversion. Furthermore, Masset and Henderson (2010) limit their analysis to world equities and art works whereas our analyses consider both house and bond prices, and differentiate between US and UK equities.

Methodologically, we apply both mean-variance (MV) rule and SD test to examine whether wine is a better choice in the investment for investors. The main analysis suggests that wine is the best investment among all individual assets we studied in this paper, including SP 500, FTSE 100, Gold, House, and Bond. We find that investors prefer to invest in with-wine portfolios than without-wine portfolios to gain higher expected utility when short sale is not

allowed. Further analyses based on the MV and SD approaches imply that investors are indifferent between portfolios with and without wine when short-selling is allowed. We examine further whether wine is important in the portfolios when comparing the performance with individual assets. Results indicate that generally wine portfolios either dominate individual assets or indifferent from individual assets. Importantly, we observe some cases in which the with-wine portfolios first-order SD (FSD) dominate House in both long-only and short-allowed strategies and this observation is not relevant for all without-wine portfolios. This probably implies that the market is not efficient and thus there is an expected arbitrage opportunity (Guo, et al., 2017) if investors include wine in their investment. Lastly, we find that investors prefer the low-risk with-wine portfolios to the equal-weighted portfolio, but they are indifferent between the high-risk with-wine portfolios and the naïve portfolio for both long-only and short-allowed strategies. Further, investors prefer the low-risk without-wine portfolios to the naïve portfolio, and no difference exists between the medium-risk without-wine portfolio and the naïve portfolio. Yet, investors prefer the naïve portfolio to high-risk without-wine portfolios for both long-only and short-allowed strategies. Taken together, wine plays a very important role in the portfolio investment in the sense that investors will never prefer the naïve portfolio to any with-wine portfolios but they do for some high-risk without-wine portfolios for both long-only and short-allowed strategies.

The rest of the paper is organized as follows. Section 2 provides a concise review of the related literature. Section 3 presents the data and empirical methodology. Section 4 discusses the empirical results. Finally, Section 5 concludes.

2. Literature Review

This paper is mainly related to two strands of research, namely price discovery in the wine market and the integration of the wine market with traditional assets. Both of these strands are related to optimal portfolio choice of wine investment.

Prior studies show that wine prices are affected by several economic and financial factors. The role of specific macroeconomic variables, such as the demand growth from emerging

economies and the abundant global liquidity, is indicated by Cevik and Sedik (2014). In addition to the importance of the demand from emerging markets which is also reported by Bouri and Azzi (2013), Jiao (2016) shows that a weaker US dollar influences fine wine prices. Furthermore, Faye et al. (2015) argue that global equity prices have a strong effect on wine prices. However, a major strand of research is motivated by the view that wine prices are also driven by non-financial factors such as the name of the producer, weather, year of vintage, grape composition, acidity, reputation, aging, and production technology (Ali et al. 2008; Bombrun and Summer, 2003; Hadj et al., 2008; Roma et al. 2013; Storchmann, 2012). Climate change also affects the quality and price of fine wines (Ashenfelter and Storchmann, 2014). Most of those studies indicate that fine wines are weakly correlated or uncorrelated with conventional assets, suggesting that wine investment is very useful for portfolio diversification strategy.

Interestingly, some other studies argue that the tangibility of fine wines makes it, like real assets, eligible to perform well in inflationary periods when traditional assets - stocks and bonds - tend to perform poorly (Roseman, 2012). According to Trellis Wine Investments (2013), fine wines are weakly positively correlated with the US consumer price index and provide a hedge against inflation risk. They also show that fine wines are not sensitive to the US stock market volatility, as measured by the VIX. Erdos and Ormos (2013) argue that the interest in fine wines as investment can be partially explained by the belief that fine wines are recession-proof if one considers the outperformance of fine wines in the period that precedes the global financial crisis. Burton and Jacobsen (2001) show that wine outperforms US bonds and that wine returns are negatively related to stock market rises.

Another important strand of research examines the relationship between wine returns and other assets returns and the direct effect on portfolio diversification. Relying on the mean/variance paradigm, Fogarty (2007) points to the benefits resulting from adding wine investment to a portfolio consisting of stocks and bonds. Using the Capital Asset Pricing and the Fama-French three factor models, Sanning et al. (2008) argue that fine wine can serve as a hedging asset against equity movements mostly because wine returns have a beta close to zero. Fogarty (2010)

indicates that wine investment can still provide a shy diversification benefit, despite wine returns are lower than the returns on standard financial assets. Masset and Weisskop (2010) show the benefits of adding fine wines to a standard portfolio of stocks and bonds through the analysis of risk and return, while accounting for the effect of the economic downturns of 2001-2003 and 2007-2009. The authors also indicate that the market returns on fine wines outperform that on stocks and bonds during stress periods. Masset and Henderson (2010) use data from 1996–2007 and highlight the risk-reduction benefits of wine investment diversification. The authors also compute optimal portfolios that include equity, wine, and art accounting for the four moments of the return distribution. Kourtis et al. (2012) report that fine wines are not only uncorrelated with conventional assets but also favorably taxed. Using several Liv-ex indices over the period 2001-2010 and 21 country equity indices, Chu (2014) highlights the diversification benefits of fine wines against equity portfolio, although the benefits are shown to differ across countries. Bouri (2015) provides evidence that wine investment can offer the highly appreciated benefits of portfolio diversification during time of crisis. Jureviciene and Jakavonyte (2016) use a dataset of US equities, bonds, and wine indices from 1993-2012 and highlight the diversification benefits of fine wines, especially in the period after the global financial crisis. Relying on the mean-variance portfolio optimization approach of Markowitz (1952) and using data from 2004 to 2014, Aytaç et al. (2016) indicate that adding wine to equity and bond portfolios makes them more efficient, while adding gold has no significant effect. However, Dimson et al. (2015) show that, for the period 1900-2012, wine investment return exceeds bonds, art, and stamps return but not that of equities. They also report a positive correlation between wine investment and equities, which can potentially hinder any diversification strategy.

The above literature review highlights important issues. First, although the relationship between fine wines and traditional financial assets is shown to be weak or negative in many cases, there is no general consensus about the importance of including wine investment in a portfolio. Second, using correlation coefficients and the asset pricing models cannot explain wine returns correctly (Sanning et al., 2008). Wine returns depart from normality, which makes

any specific assumption about the utility function to describe the investor's preferences unrealistic, especially given that investors might have sophisticated preferences and thereby optimize their decision making using full information rather than just the first and second moments. This suggest the suitability of applying a non-parametric approach like the SD. Accordingly, in this paper, we apply a SD-based approach on a relatively broader set of assets to capture the stylistic facts of wine returns. We allow short selling and examine a multitude of portfolios that include US and UK equities, bonds, gold, and house prices. By doing so, we offer a more realistic and practical analysis on wine portfolio choices to market participants who have sophisticated risk preferences.

3. Data and Methodology

In this section, we discuss our dataset and the methodology we used to analyse the data. We first discuss our dataset.

3.1. Data

Our data set covers the monthly period of 1990:06 to 2016:04, with the start and end date being determined by the availability of data on the wine prices. Besides wine prices, our dataset includes stock prices, house prices, gold prices,and government bond yields. Specifically, stock prices correspond to the S&P500, house prices are represented by the S&P/CoreLogic/Case-Shiller index, and government bond yields measure the ten-year long-term government bond yield, with these three variables extracted from the data segment of Professor Robert J. Shiller.[3] Gold prices are obtained from the FRED database of the Federal Reserve Bank of St. Louis, and correspond to the Gold Fixing Price 3:00 P.M. (London time) in London Bullion Market in the US dollars. Finally, wine prices are represented by the Liv-ex Fine Wine Investables (Liv-ex Investables) index, which tracks the most "investable" wines in the market around 200 wines from 24 top Bordeaux chateaux. In essence, this wine index aims to mirror the performance of a typical wine investment portfolio. Wine data are obtained from DataStream maintained by Thomson Reuters. All the prices are converted to log-returns, i.e., first-

[3] http://www.econ.yale.edu/~shiller/data.htm

differences of the natural logs of the prices; while, we divide the bond yields by 1200, since the bond data is originally available in annualized rate form.

3.2. Methodology

We first define U_j used in our paper in which U_j is the set of utility functions such that $U_j = \{u : (-1)^{i+1} u^{(i)} \geq 0, i = 1, \text{L} \ , j\}$, where $u^{(i)}$ is the i^{th} derivative of the utility function U. In this paper, we will use the mean-variance (MV) rule, the classical portfolio optimization (PO), and stochastic dominance (SD) test. We first discuss the MV rule.

3.2.1 Mean-variance (MV) criteria

For the returns Y and Z of any two assets or portfolios with means μ_y and μ_z and standard deviations σ_y and σ_z, the MV rule (Markowitz 1952) is: Y is said to dominate Z by the MV rule if $\mu_y \geq \mu_z$ and $\sigma_y \leq \sigma_z$ and if the inequality holds in at least one of the two conditions. Wong (2007) show that if X dominates Y by the MV rule, then risk averters with $u^{(1)} > 0$ and $u^{(2)} < 0$ will attain higher expected utility by holding X than Y under certain conditions. The theory can be extended to non-differentiable utilities (Wong and Ma, 2008).

3.2.2 Mean-variance portfolio optimization (PO)

The classical portfolio optimization (PO) model introduced by Markowitz (1952), and improved by Bai et al. (2009), Leung et al. (2012) and others can be used to determine the asset allocation for a given amount of capital through the efficient frontier. To present the PO model formally, we assume that there are n assets in which x_i ($i=1,\ldots,n$) is the fraction of the capital invested in asset i of portfolio P with the average return R_p to be maximized subject to a given level of risk (represented by its variance) σ_p^2. We denote R_i the expected return of asset i and σ_{ij} the covariance of returns between assets i and j for any $i, j = 1,\ldots,n$. The optimal return can be obtained by solving the following equation:

Max $R_p = \sum_{i=1}^{n} R_i x_i$ subject to: $\sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{ij} x_i x_j = \sigma_p^2$ and $\sum_{i=1}^{n} x_i = 1$.

If a short sale is not allowed, we add an additional condition: $x_i \geq 0, i = 1, \ldots n$. After constructing the efficient frontiers, we will choose 15 efficient portfolios with and without wine and compare their performance by using both MV and SD criterion, regardless of whether a short sale is used)

3.2.3 Stochastic dominance (SD) approach

Let *X* and *Y* represent the returns of two assets or portfolios with a common support of $\Omega = [a, b]$ ($a < b$), the cumulative distribution functions (CDFs), *F* and *G*, and the corresponding probability density functions (PDFs), *f* and *g*, respectively, we define

$$H_0 = h, \quad H_j(x) = \int_a^x H_{j-1}(t)dt \tag{1}$$

for $h = f, g$; $H = F, G$; and for any integer j.

We call the integral H_j the j^{th}-order integral for $H = F, G$. *Y* is said to dominate *Z* by FSD (SSD, TSD) denoted by

$$Y \succ_1 Z, (Y \succ_2 Z, Y \succ_3 Z) \tag{2}$$

if $F_1(x) \leq G_1(x)$ ($F_2(x) \leq G_2(x), F_3(x) \leq G_3(x)$) for all possible returns *x*, and the strict inequality holds for at least one value of *x* and the strict inequality holds for at least one value of *x*. where FSD (SSD, TSD) denotes first-order (second-order, third-order) SD, respectively. For $Y \succ_3 Z$, we need one more condition: $\mu_Y \geq \mu_Z$. Readers may refer to Levy (2015), Guo and Wong (2016) and the references therein for more information on the SD definitions for any order.

3.2.3.1 Stochastic dominance test

The SD tests have been well developed (Davidson and Duclos, DD, 2000) to allows the statistical significance to be determined. Since the SD test developed by DD is found to be powerful, less conservative in size, and robust to non-i.i.d. and heteroscedastic data (Lean et

al., 2008) while Bai, et al. (2015) derive the limiting process of the DD statistic when the underlying processes are dependent or independent, we employ their SD tests in our study.

Let $\{f_i\}(i = 1,2,\cdots n_f)$ and $\{g_i\}\left(i = 1,2,\cdots n_g\right)$ are observations drawn from the returns of any two assets or portfolios *Y* and *Z* with CDFs *F* and *G*, respectively. For a grid of pre-selected points $x_1, x_2 \ldots x_k$, the j^{th}-order SD test statistic, $T_j(x)$ (j = 1, 2, and 3) is defined as:

$$T_j(x) = \frac{\hat{F}_j(x) - \hat{G}_j(x)}{\sqrt{\hat{V}_j(x)}} \qquad (3)$$

where

$$\hat{V}_j(x) = \hat{V}_{F_j}(x) + \hat{V}_{G_j}(x) - 2\hat{V}_{FG_j}(x);\ \hat{H}_j(x) = \frac{1}{N_h(j-1)!}\sum_{i=1}^{N_h}(x - h_i)_+^{j-1},$$

$$\hat{V}_{H_j}(x) = \frac{1}{N_h}\left[\frac{1}{N_h((j-1)!)^2}\sum_{i=1}^{N_h}(x - h_i)_+^{2(j-1)}\hat{H}_j(x)\right]^2; H = F, G; h = f, g;$$

$$\hat{V}_{FG_j}(x) = \frac{1}{N_h}\left[\frac{1}{N_h((j-1)!)^2}\sum_{i=1}^{N_h}(x - f_i)_+^{j-1}(x - g_i)_+^{j-1} - \hat{F}_j(x)\hat{G}_j(x)\right],$$

F_j and G_j are defined in (2). For all $i = 1,2,\ldots,k;$ we test the following hypotheses:

$$\begin{aligned}
&H_0 : F_j(x_i) = G_j(x_i)\ , \text{ for all } x_i;\\
&H_A : F_j(x_i) \neq G_j(x_i) \text{ for some } x_i;\\
&H_{A1} : F_j(x_i) \leq G_j(x_i) \text{ for all } x_i, F_j(x_i) < G_j(x_i) \text{ for some } x_i;\\
&H_{A2} : F_j(x_i) \geq G_j(x_i) \text{ for all } x_i, F_j(x_i) > G_j(x_i) \text{ for some } x_i.
\end{aligned} \qquad (4)$$

Not rejecting either H_0 or H_A implies the non-existence of any SD relationship between X and Y. If $H_{A1}(H_{A2})$ of order one is accepted, $X(Y)$ stochastically dominates $Y(X)$ at first order. If H_{A1} (H_{A2}) is accepted at order two (three), a particular distribution stochastically dominates the other at second- (third-) order. Readers may refer to Bai et al. (2015) for the decision rules and more information on the tests. Bai et al. (2015) derive the limiting process of the SD statistic $T_j(x)$ so that the SD test can be performed by using $\max_x|T_j(x)|$ to take

care of the dependency of the partitions. We follow their recommendation in our analysis. On the other hand, Fong et al. (2005) and others recommend to a limited number (100) of grids for comparison, we adopt their practice also. In order to minimize Type II errors and to accommodate the effect of almost SD (Leshno and Levy, 2002; Guo, et al., 2013, 2014, 2016), we follow Gasbarro et al. (2007), Chan, et al. (2012), Clark, et al. (2016) and others to use a conservative 5% cut-off point in examining the proportion of test statistics to draw inference. We also follow the approach used in Chan, et al. (2016) on how to test for the third order SD.[4]

4. Empirical Findings

Before we examine the preference of portfolios with and without wine for investors via both MV and SD tests, we first examine the preference for all individual assets being studied in this paper.

4.1 Preference for individual assets

We refer to the characteristics of the return for each individual asset.

Table 1: Descriptive statistics for individual assets

	Mean	s.d.	Skewness	Kurtosis	JB
Wine	0.0087***	0.0311	1.6741***	14.2816***	2788.33***
SP500	0.0056**	0.0422	-0.7912***	1.7391***	71.64***
FTSE100	0.0031	0.0407	-0.5858***	0.6216*	22.8***
Gold	0.0039*	0.0357	0.3983**	1.6471**	43.38***
House	0.0036***	0.0118	0.1064	1.0566***	15.05***
Bond	0.0040***	0.0015	0.1089	-0.8303***	9.55***

Note: This table reports the summary statistics including the mean, standard deviation (s.d.), skewness, excess kurtosis, and Jarque-Bera (JB) test. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

[4] Readers may refer to Chan, et al. (2016) for more information on the test.

As shown in Table 1, the returns of all individual assets except FTSE100 are significantly positive. Among them, Wine has the highest return (0.0087) and (the fourth) high standard deviation (00311) over the entire period in our study. The returns of Gold, House, and Bond are not rejected to be the same. However, the standard deviations of both SP500 and FTSE 100 are very high (more than 0.04), while that of Bond is very small (0.0015). In addition, Wine and Gold have significantly positive skewness, Wine has the highest significantly positive skewness, and both SP500 and FTSE100 have significantly negative skewness. On the other hand, all individual assets except Bond have significantly higher kurtosis and, as expected, Bond has the significantly smallest kurtosis among all assets and smaller than normal distribution. The excess kurtosis of Wine is extremely high, implying that the distribution of wine return is seriously fat-tailed and its price is highly volatile.

4.1.1 Mean-variance (MV) criteria for individual assets

To examine the preference for all individual assets being studied in this paper, we first apply the MV rule (Markowitz, 1952) to study the preference of different individual assets and report the results in Table 2. The results could be used to infer the preference of different assets for investors under certain conditions (Wong et al., 2008).

Table 2: Mean-variance analysis of individual assets

	SP500	FTSE100	Gold	House	Bond
Wine	1.0292 0.5414***	1.9017** 0.5835***	1.7736** 0.7551***	2.6744*** 6.8838***	2.6691*** 423.42***
SP500		0.7398 1.0778	0.5432 1.3948***	0.7972 12.716***	0.6879 782.15***
FTSE100			-0.2460 1.2941**	-0.1985 11.798***	-0.3515 725.68***
Gold				0.1303 9.117***	-0.0276 560.78***

House					-0.4940 61.509***

Note: The upper (lower) value in each cell presents the estimate or the value of t test (F test). The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

The pairwise comparison in Table 2 shows that the mean return of Wine is higher than all other assets and significantly higher than all other assets except SP500 (which is not rejected to be the same as Wine). There is no significant difference between any other pair of assets for the mean. On the other hand, all the estimates of the Fisher-F test are significant, except the pair of SP500 and FTSE100. Thus, by using the MV criterion, we conclude the following: investors prefer 1) Wine to SP500, FTSE100 and Gold; 2) Gold, House, and Bond to SP500 and FTSE100; 3) House and Bond to Gold; 4) and Bond to House but 5) indifferent between SP500 and FTSE100, Wine and House, and Wine, and Bond. Since the main purpose of our paper is to study the preference of portfolios with and without wine, we focus more on the findings that show investors (a) prefer Wine to SP500, FTSE100, and Gold in term of both mean and variance, and (b) prefer Wine to House and Bond in terms of mean only. Thus, based on the MV analysis, we confirm that wine is the best investment among all individual assets we studied.

4.1.2 Stochastic dominance (SD) criteria for individual assets

We notice from Table 1 that the Jarque-Bera (JB) statistic shows that the distributions of the returns of all assets are not normal distributed, especially for Wine, suggesting that the conclusion drawn from the mean-variance analysis may not be meaningful. Thus, we turn to apply the SD test to examine the preference of individual assets and report the results in Table 3. Overall, we find that: 1) Wine stochastically dominates SP 500, FTSE 100, and Gold in the sense of both second and third orders; 2) investors prefer Bond to all the other assets except Wine; 3) House dominates SP 500, FTSE 100, and Gold; 4) Gold dominates both SP 500 and FTSE 100; 5) there is no difference between SP 500 and FTSE 100, and between Wine and

both House and Bond. From the SD results, we conclude that Bond (dominates 4 assets) is the best choice for investors, followed by Wine (dominates 3 assets) and House (dominates 3 assets). In addition, since the main purpose of our paper is to study the preference of individual assets and portfolios with and without wine, we care more on the findings that Wine stochastically dominates SP 500, FTSE 100 and Gold in the sense of second and third orders, and there is no difference between Wine and House or Bond. Nonetheless, the mean of Wine is significantly bigger than those of House and Wine. We have also conducted SD test for risk seekers, and find that risk-seeking investors prefer Wine to both House and Bond.[5] Thus, we conclude that wine is the best choice among all the assets we analyzed in our study by using the SD approach.

In short, our MV and SD analyses suggest that Wine is the best investment among all individual assets we studied in this paper, including SP 500, FTSE 100, Gold, House, and Bond.

Table 3: SD results for individual assets

	SP500	FTSE100	Gold	House	Bond
Wine	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\neq$	$\neq$
SP500		$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
FTSE100			$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
Gold				$\prec_{2,3}$	$\prec_{2,3}$
House					$\prec_{2,3}$

Note: This table reports the stochastic-dominance (SD) results to test whether there is any *j*-order stochastic dominance between any pair of assets for *j* = 1, 2, 3. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{2,3}$ is defined in (2), and $\prec_{2,3}$ is reverse of $\succ_{2,3}$ such that $Y \prec_{2,3} Z$ means $Y \succ_{2,3} Z$, the first cell infers *Wine* $\succ_{2,3}$ *S&P500* and the last cell infers *House* $\prec_{2,3}$ *Bond*. The rest of the cells can be read in a similar way.

[5] We do not report the SD test for risk seekers since our paper mainly studies the preference for risk averters. Readers may refer to Qiao, et al (2012), Hoang, et al. (2015), and Bai, et al. (2015) on how to conduct the SD test for risk seekers.

4.2 Preference for portfolios with and without wine

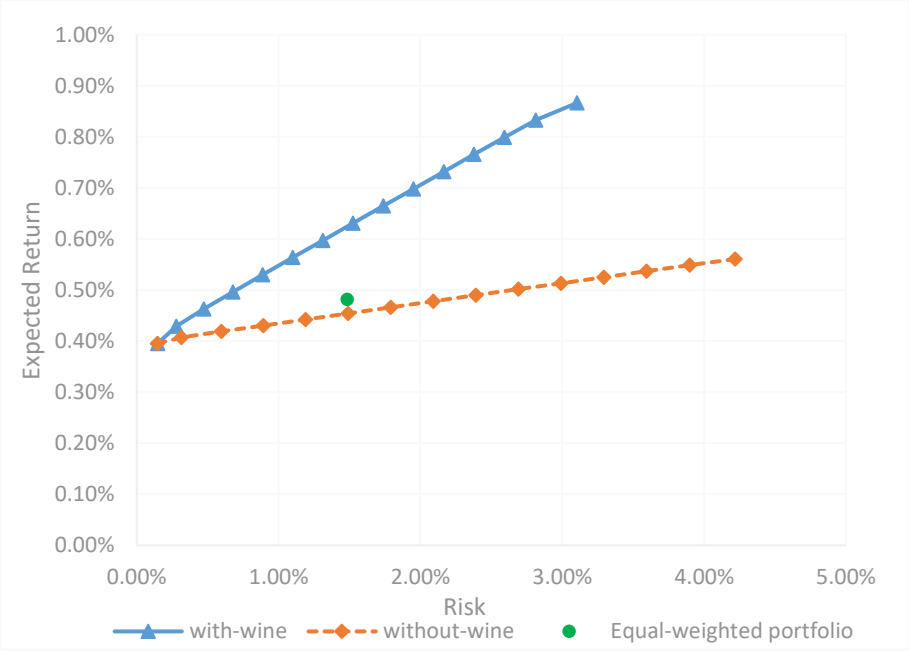
We turn to examine the preference of portfolios with and without wine and compare the preference of portfolios with the equal-weighted portfolio. Before we make the comparison, we first construct frontiers of portfolios with and without wine as shown in next subsection.

4.2.1 Mean-variance portfolio optimization (PO)

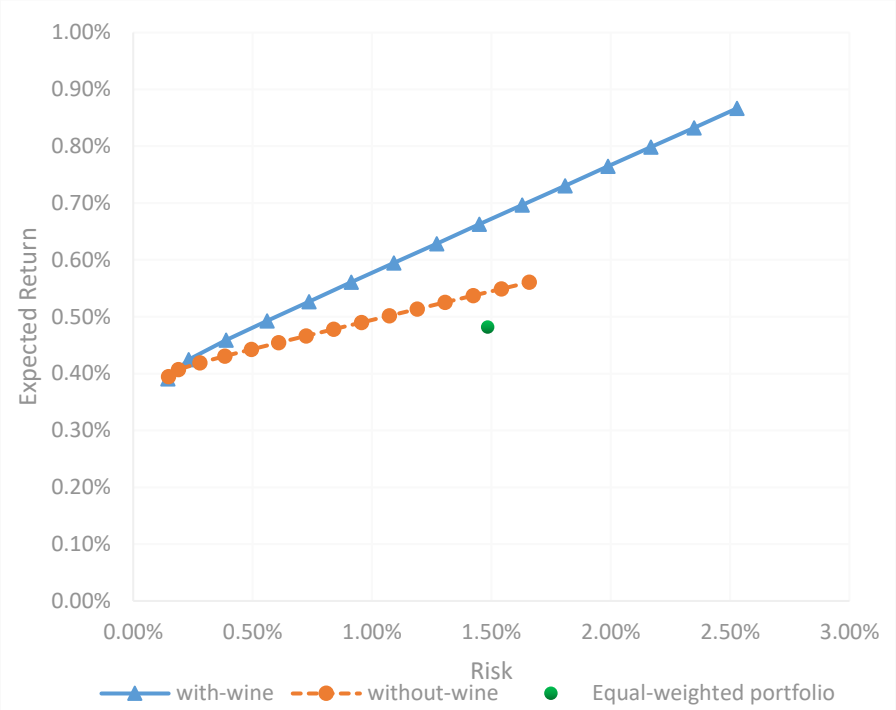
In order to examine investors' preferences between portfolios with and without wine, we first adopt the portfolio optimization (PO) approach to estimate the MV efficient frontiers for (A) long-only (no short sale is performed) and (B) short sale allowed (short sale is allowed) strategies and plot the estimates of the frontiers of portfolios (that is, the portfolios with the highest expected rate of return for any given level of risk) with and without wine for A and B in Panels A and B of Figure 1.

Figure 1: Mean Variance Efficient Frontiers

A. Long-only strategy



B. Short-allowed strategy



From Panels A and B of Figure 1, we observe that the efficient frontiers with wine are on top of those without wine for both long-only and short sale allowed strategies while both frontiers are on top of the equal-weighted portfolio. Based on the modern finance theory, see, for example, Markowitz (1952), one may believe that portfolios with wine are more profitable than those without wine, regardless whether short sale is allowed or not. Thus, based on modern finance theory and the efficient frontiers, we conclude that the portfolios with wine are better than both the equal-weighted portfolio and the portfolios without wine, regardless whether short sale is allowed or not.

Is the conclusion drawn by the visual analysis correct? In this paper, we would like to examine whether this is true. To do so, we partition each efficient frontier (with and without wine and regardless of whether a short sale is allowed) into 15 portfolios (from PF1 to PF15) with PF1 being the minimum-variance portfolio and PF15 being the maximum-return portfolio. The construction of the PF1-PF15 with-wine portfolios and the PF1-PF15 without-wine portfolios, we use the following steps: (1) We partition the efficient frontier in 15 slices with equal distance on the horizontal axis. (2) We then determine the 15 points (representing the portfolios) and their risk-return coordinates belonging to the above-mentioned 15 slices. As a result, we can

define the 15 efficient portfolios whose returns are equally spaced along the whole range of the efficient frontier.

4.2.2 Mean-variance (MV) criteria for portfolios with and without wine

Using the frontiers for portfolios with and without wine constructed in Section 4.2.1, we now apply both MV rule and SD test to compare the performance between each of the 15 chosen portfolios in the frontier of the portfolios with wine with the corresponding portfolios in the frontier of the portfolios without wine. We first conduct the MV rule to compare the performance between portfolios with and without wine in next section.

We first estimate some descriptive statistics for portfolios with and without wine when short sale is not allowed (long only) and when short sale is allowed (short allowed), and exhibit the results in Tables 4A and 4B, respectively. The results can be used to compare the performance of the portfolios by using the MV rule.

Table 4A: Descriptive statistics for portfolios with and without wine when short sale is not allowed

Long-only						
With-wine Without-wine	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**JB**	**t Test** **F Test**
PF1	0.0040 0.0040	0.0015 0.0015	-0.0939 -0.0911	-0.8572 -0.8583	10.098*** 10.095***	0.0131 1.0028
PF2	0.0043 0.0041	0.0028 0.0032	0.8781 -0.6840	6.2052 1.3785	519.66*** 47.185***	0.9190 0.7816**
PF3	0.0046 0.0042	0.0047 0.0060	1.2794 -0.8147	10.0377 1.8916	1343.3*** 78.043***	1.0131 0.6239***
PF4	0.0050	0.0068	1.3781	11.2629	1683.6***	1.0318

	0.0043	0.0089	-0.8276	1.9557	82.199***	0.5775***
PF5	0.0050 0.0044	0.0068 0.0119	1.3781 -0.8271	11.2629 1.9628	1683.6*** 82.499***	1.0379 0.5566***
PF6	0.0056 0.0045	0.0110 0.0149	1.4211 -0.8246	12.0156 1.9613	1909.2*** 82.214***	1.0404 0.5449***
PF7	0.0060 0.0047	0.0131 0.0179	1.4256 -0.8219	12.1557 1.9542	1952.3*** 81.639***	1.0417 0.5374***
PF8	0.0063 0.0048	0.0153 0.0209	1.4270 -0.8195	12.2420 1.9478	1978.9*** 81.13***	1.0423 0.5322***
PF9	0.0066 0.0049	0.0174 0.0239	1.4271 -0.8175	12.2987 1.9421	1996.3*** 80.688***	1.0427 0.5284***
PF10	0.0070 0.0050	0.0195 0.0269	1.4265 -0.8158	12.3378 1.9374	2008.3*** 80.317***	1.0429 0.5256***
PF11	0.0073 0.0051	0.0217 0.0299	1.4253 -0.8144	12.3656 1.9334	2016.8*** 80.003***	1.0430 0.5233***
PF12	0.0077 0.0053	0.0238 0.0329	1.4194 -0.8132	12.3780 1.9299	2019.7*** 79.733***	1.0430 0.5215***
PF13	0.0080 0.0054	0.0259 0.0360	1.4171 -0.8121	12.3926 1.9263	2023.9*** 79.469***	1.0430 0.52***
PF14	0.0083 0.0055	0.0281 0.0390	1.5319 -0.8065	13.2293 1.8549	2309.9*** 75.653***	1.0416 0.5204***
PF15	0.0087 0.0056	0.0311 0.0422	1.6741 -0.7912	14.2816 1.7391	2696*** 69.231***	1.0292 0.5414***
Pn	0.0048	0.0148	-0.6116	2.1819	2697***	

Note: The table reports the summary statistics for the 15 portfolios (PF1 to PF 15) with and without wine on the MV efficient portfolios for the long-only strategy and Pn is the naïve portfolio, including mean, standard deviation (s.d.), skewness, kurtosis, the Jarque–Bera (JB), and t and F tests. The upper (lower) value in each cell presents the estimate or the value of test for the

with-wine (without-wine) portfolio. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

Table 4B: Descriptive statistics for portfolios with and without wine when short sale is allowed

Short allowed						
With-wine Without-wine	**Mean**	**Std Dev**	**Skewness**	**Kurtosis**	**JB**	**t Test** **F Test**
PF1	0.0039 0.0039	0.0014 0.0015	0.0185 -0.0759	-0.7225 -0.8481	6.9263** 9.7418***	-0.3631 0.9673
PF2	0.0042 0.0041	0.0023 0.0019	0.2705 0.3211	1.2881 -0.1100	23.948*** 5.5038*	0.9673 1.503***
PF3	0.0046 0.0042	0.0039 0.0028	0.4055 0.3827	3.2527 0.5347	139.6*** 10.849***	1.4784* 1.9523***
PF4	0.0049 0.0043	0.0056 0.0038	0.4219 0.3548	3.9122 0.7200	199.25*** 12.62***	1.6166* 2.1334***
PF5	0.0053 0.0044	0.0074 0.0049	0.4192 0.3263	4.1830 0.7658	226.51*** 12.451***	1.6785** 2.2136***
PF6	0.0056 0.0045	0.0091 0.0061	0.4136 0.3049	4.3173 0.7719	240.53*** 11.873***	1.7121** 2.2546***
PF7	0.0059 0.0047	0.0109 0.0072	0.4082 0.2891	4.3931 0.7662	248.55*** 11.286***	1.7329** 2.2780
PF8	0.0063 0.0048	0.0127 0.0084	0.4034 0.2773	4.4401 0.7572	253.54*** 10.776***	1.7468** 2.2926***
PF9	0.0066 0.0049	0.0145 0.0096	0.3994 0.2682	4.4712 0.7478	256.84*** 10.348***	1.7567** 2.3022***
PF10	0.0070 0.0050	0.0163 0.0107	0.3960 0.2610	4.4929 0.7389	259.13*** 9.9912***	1.7641** 2.3088***

PF11	0.0073 0.0051	0.0181 0.0119	0.3931 0.2552	4.5087 0.7309	260.79*** 9.6922***	1.7698** 2.313***
PF12	0.0076 0.0053	0.0199 0.0131	0.3906 0.2504	4.5205 0.7236	262.02*** 9.4394***	1.7744** 2.3172***
PF13	0.0080 0.0054	0.0217 0.0142	0.3885 0.2464	4.5296 0.7171	262.96*** 9.2236***	1.7781** 2.32***
PF14	0.0083 0.0055	0.0235 0.0154	0.3866 0.2431	4.5368 0.7114	263.7*** 9.0378**	1.7811** 2.3221***
PF15	0.0087 0.0056	0.0253 0.0166	0.3850 0.2401	4.5426 0.7062	264.29*** 8.8763**	1.7837** 2.3238***
Pn	0.0048	0.0148	-0.6116	2.1819	2697***	

Note: The table reports the summary statistics for the 15 portfolios (PF1 to PF 15) with and without wine on the MV efficient portfolios for the short-allowed strategy and Pn is the naïve portfolio, including mean, standard deviation (s.d.), skewness, kurtosis, the Jarque–Bera (JB), and t and F tests. The upper (lower) value in each cell presents the estimate or the value of test for the with-wine (without-wine) portfolio. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

Table 4A (long-only strategy) presents the descriptive statistics and the MV rule for returns for 15 efficient portfolios with and without wine. From the table, we find that for the long-only strategy, the returns and standard deviations of portfolios with (without) wine vary from 0.004 to 0.0087 (0.004 to 0.0056) and from 0.0015 to 0.0311 (0.0015 to 0.0422), respectively. This shows that all portfolios with wine generate higher returns but smaller risk than those without wine (except PF1). However, the results of the Student t-test and Fisher F-test show that the difference of returns is not significant, while it is significant for the variances, between portfolios with wine and without wine (except for PF1 in which both t and F tests are not significant). Thus, we can conclude that including wine in a portfolio has a significant impact on the volatility of returns, but not on the returns.

Using the t and F tests and applying the MV rule, from Table 4A we conclude that for long-only strategy investors would prefer portfolios with wine, since they provide smaller risk with the same or higher return. This shows that the traditional financial theory is correct that investors prefer to invest in the more-diversified portfolio (with Wine), and thus, prefer to invest in portfolios (with Wine) in the frontier that are higher than portfolios (without Wine) in lower frontier.

We turn to examine the preference of portfolios with and without wine when short sale is allowed for investors. To do so, we present in Table 4B the descriptive statistics for returns for 15 efficient portfolios with and without wine when short sale is allowed. From the table, we find that when short sale is allowed, all portfolios with wine generate higher returns and also higher risk than those without wine (except PF1). From Table 4B, we find that except PF1, Fisher F-test show that the variances of the returns are significantly (at 1%) smaller for each efficient portfolio without wine than the correspondence efficient portfolio with wine when short sale is allowed. On the other hand, t test shows that the mean of the return is still not significant for the smaller risk portfolios (PF1-PF2) but then become marginally and significantly (at 10%) higher for the larger risk portfolios (PF3-PF4) and significantly (at 5%) higher for the much larger risk portfolios (PF5-PF15) for each efficient portfolio with wine than the correspondence efficient portfolio without wine when short sale is allowed. Apply the MV rule and if we use 1% significant value, we can conclude that, in general, when short sale is allowed, investors would prefer portfolios without wine. Nonetheless, if we use 10% or 5% significant value, then we can conclude that when short sale is allowed, investors are indifferent to portfolios with wine and without wine. We note that using the MV rule risk seekers, we conclude that risk seekers would prefer portfolios with wine in most of the case. Thus, overall, using the MV rule, we conclude that when short sale is allowed, investors are indifferent to portfolios with wine and without wine. Or at least, we can conclude that using the MV rule, except PF2, when short sale is allowed, investors are indifferent to portfolios with wine and without wine.

Table 4C: The results of MV analysis between portfolios with and without wine

With-Wine	**Long-only**	**Short-allowed**	Without-Wine
PF1	=	=	PF1
PF2	≻	≺	PF2
PF3	≻	=	PF3
PF4	≻	=	PF4
PF5	≻	=	PF5
PF6	≻	=	PF6
PF7	≻	=	PF7
PF8	≻	=	PF8
PF9	≻	=	PF9
PF10	≻	=	PF10
PF11	≻	=	PF11
PF12	≻	=	PF12
PF13	≻	=	PF13
PF14	≻	=	PF14
PF15	≻	=	PF15
PF16	≻	=	PF16

Note: We use 10% or 5% significant values to obtain the MV results.

4.2.3 Stochastic dominance (SD) criteria for portfolios with and without wine

Since the estimates of skewness, kurtosis, and the Jarque-Bera test (exhibited in Tables 4A and 4B) show that the distributions of returns for all portfolios are not normally distributed, and thus, the findings based on the MV approach may be misleading. To circumvent this limitation, we apply the SD approach to compare the performance between portfolios with and without wine.

Using the frontiers for portfolios with and without wine constructed in Section 4.2, we now apply the SD test to compare the performance between each of the 15 chosen portfolios in the frontier of the portfolios with wine with the corresponding portfolios in the frontier of the portfolios without wine. We first examine the case when short sale is not allowed and exhibit the results in Table 5. From the table, the SD results show that when using long-only strategy, we have: (1) for PF1, there is no difference between with- and without-wine portfolios; (2) for PF2-PF15, with-wine portfolios stochastically dominate without-wine portfolios at the second and third orders.

The SD results are consistent with the results obtained by using the MV criterion but it provides more information. The SD results infer that when short sales are not allowed, the traditional financial theory is correct that the second- and third-order risk averters[6] prefer to invest in more-diversified portfolios (with Wine), and thus, prefer to invest in the (with-wine) portfolios in the frontier higher than the (without-wine)portfolios in lower frontier.

We turn to apply the SD test to examine the preference of portfolios with and without wine when short sale is allowed and exhibit the results in Table 5. From the table, when short sales are allowed, there is no difference between portfolios with- and without-wine for all portfolios.

In short, our MV and SD results imply that, in general, the traditional financial theory is correct that the second- and third-order risk averters prefer to invest in with-wine portfolios than without-wine portfolios when short sale is not allowed. However, investors are indifferent between portfolios with and without wine when short sale is allowed. This shows that the visual conclusion may not hold true.

Table 5: Stochastic dominance analysis between portfolios with and without wine for long only and short sale is allowed

	Long-only	**Short-allowed**	

[6] Readers may refer to Wong (2008) and Guo and Wong (2016) for the definition.

With-Wine	**Dominant Relationship**		Without-Wine
PF1	=	=	PF1
PF2	$\succ_{2,3}$	=	PF2
PF3	$\succ_{2,3}$	=	PF3
PF4	$\succ_{2,3}$	=	PF4
PF5	$\succ_{2,3}$	=	PF5
PF6	$\succ_{2,3}$	=	PF6
PF7	$\succ_{2,3}$	=	PF7
PF8	$\succ_{2,3}$	=	PF8
PF9	$\succ_{2,3}$	=	PF9
PF10	$\succ_{2,3}$	=	PF10
PF11	$\succ_{2,3}$	=	PF11
PF12	$\succ_{2,3}$	=	PF12
PF13	$\succ_{2,3}$	=	PF13
PF14	$\succ_{2,3}$	=	PF14
PF15	$\succ_{2,3}$	=	PF15
PF16	$\succ_{2,3}$	=	PF16

Note: This table reports the stochastic-dominance (SD) results to test whether with-wine portfolios strictly dominate without-wine portfolios at the *j*-order stochastic dominance for $j = 1, 2, 3$. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{2,3}$ is defined in (2), and = means "is indifferent from". For example, the fourth row infers that the with-wine portfolio PF2 strictly dominate without-wine portfolio PF2 at the second- and third-order stochastic dominance when using the "long-only" strategy but they are indifference when using the "short-allowed" strategy. The rest of the cells can be read in a similar way. Portfolios PF1 to PF15 are defined in Section 4.2.1.

4.3 Preference between individual assets and portfolios with and without wine

In this section, we mainly discuss the preference for individual assets and portfolios with wine since our paper mainly studies whether Wine a good choice for investment. However, we find that the results for the preference for individual assets and portfolios without wine are

interesting, and the results can be used for the comparison for the preference for individual assets and portfolios with wine, and thus, we will briefly discuss the result.

4.3.1 Mean-variance (MV) criteria for individual assets and portfolios with and without wine

We first apply the MV criterion to compare the performance between individual assets and portfolios with wine and without wine.

4.3.1.1 Mean-variance (MV) criteria for individual assets and portfolios with wine

We first apply the MV criterion to compare the performance between the portfolios with wine and individual assets and exhibit the results in Tables 6A and 6B for the case when short sale is not allowed and allowed, respectively.

Table 6A: Mean-variance analysis of individual assets and portfolios with wine when short sale is not allowed

With-wine	SP500	FTSE100	Gold	House	Bond	**Pn**
PF1	-0.6901 0.0012***	0.3492 0.0013***	0.0250 0.0017***	0.4863 0.0156***	-0.0447 0.9569	-1.0218 0.0099***
PF2	-0.5488 0.0044***	0.4943 0.0047***	0.1905 0.0061***	0.9649 0.0558***	1.8385** 3.4298***	-0.6161 0.0355***
PF3	-0.4068 0.0126***	0.6371 0.0135***	0.3540 0.0175***	1.3862* 0.1596***	2.3722*** 9.8163***	-0.2163 0.1016***
PF4	-0.2654 0.0259***	0.7766 0.0279***	0.5139 0.0361***	1.7297* 0.3291***	2.5459*** 0.242***	0.1573 0.2094***
PF5	-0.1254	0.9118	0.6688	1.9954**	2.6220***	0.4914

	0.0444***	0.0478***	0.0619***	0.5641***	34.697***	0.3589***
PF6	0.0120 0.0680***	1.0418 0.0733***	0.8174 0.0948***	2.1948** 0.8645	2.6627*** 53.173***	0.7813 0.5501***
PF7	0.1461 0.0967***	1.1660 0.1043***	0.9586 0.1349***	2.3425*** 1.2302*	2.6873*** 75.668***	1.0281 0.7828**
PF8	0.2762 0.1306***	1.2838 0.1408***	1.0920 0.1822***	2.4517*** 1.6613***	2.7035*** 102.18***	1.2360 1.0571
PF9	0.4015 0.1697***	1.3950 0.1829***	1.2170 0.2367***	2.5329*** 2.1577***	2.7149*** 132.72***	1.4104* 1.3730**
PF10	0.5217 0.2139***	1.4993 0.2305***	1.3335 0.2983***	2.5938*** 2.7194***	2.7233*** 167.27***	1.5569* 1.7305***
PF11	0.6366 0.2632***	1.5968* 0.2837***	1.4415* 0.3671***	2.6399*** 3.3466***	2.7297*** 205.84***	1.6803** 2.1295***
PF12	0.7457 0.3177***	1.6874** 0.3424***	1.5413* 0.4431***	2.6749*** 4.0397***	2.7345*** 248.48***	1.7847** 2.5706***
PF13	0.8492 0.3733***	1.7715** 0.4067***	1.6331* 0.5262***	2.7022*** 4.7978***	2.7384*** 295.11***	1.8738** 3.0529***
PF14	0.9463 0.4442***	1.8478** 0.4788***	1.7158** 0.6196***	2.7178*** 5.6485***	2.7351*** 347.33***	1.9466** 3.5943***
PF15	1.0292 0.5414***	1.9017** 0.5835***	1.7736** 0.7551**	2.6744*** 6.8838***	2.6601*** 423.42***	1.9712** 4.3804***

Note: Pn is the naïve portfolio. The upper (lower) value in each cell presents the estimate or the value of t test (F test). The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

From Table 6A, we find that if 5% or 1% significant levels are used, we conclude that investors: 1) prefer with-wine PF1-PF15 portfolios to SP500, FTSE100, and Gold; 2) they prefer with-

wine PF1-PF7 portfolios to House but indifference to PF8-15 and House; and 3) there is no difference between PF1-PF15 and Bond.

Similarity, from Table 6B, when short sale is allowed, we obtain the similar conclusion to the long-only strategy as shown in Table 6A by using the MV criterion. We make the following conclusions: 1) investors prefer with-wine PF1-PF15 portfolios to SP500, FTSE100, and Gold; 2) they prefer with-wine PF1-PF7 portfolios to House but indifference to PF8-15 and House; and 3) there is no difference between with-wine PF1-PF15 portfolios and Bond.

Table 6B: Mean-variance analysis of individual assets and portfolios with wine when short sale is allowed

With-wine	SP500	FTSE100	Gold	House	Bond	**Pn**
PF1	-0.7095 0.0012***	0.3291 0.0013***	0.0021 0.0016***	0.4178 0.0149***	-0.4369 0.9177	-1.0769 0.0095***
PF2	-0.5671 0.0030***	0.4760 0.0032***	0.1694 0.0042***	0.9100 0.0381***	1.8404** 2.3448***	-0.6701 0.0243***
PF3	-0.4242 0.0085***	0.6213 0.0091***	0.3355 0.0118***	1.3620* 0.1077***	2.6567*** 6.6263***	-0.2654 0.0686***
PF4	-0.2815 0.0176***	0.7643 0.0190***	0.4990 0.0245***	1.7535** 0.2237***	2.9430*** 13.7620***	0.1213 0.1424***
PF5	-0.1399 0.0304***	0.9043 0.0327***	0.6590 0.0424***	2.0776** 0.3862***	3.0709*** 23.7520***	0.4780 0.2457***
PF6	0.0000 0.0468***	1.0404 0.0504***	0.8143 0.0653***	2.3378*** 0.5950***	3.1394*** 36.5960***	0.7983 0.3784***
PF7	0.1374 0.0669***	1.1722 0.0721***	0.9642 0.0933***	2.5428*** 0.8502***	3.1807*** 52.295***	1.0804 0.5410***
PF8	0.2719	1.2992*	1.1079	2.7030***	3.2079***	1.3257*

	0.0906***	0.0976***	0.1263***	1.1518***	70.848***	0.7329***
PF9	0.4028 0.1180***	1.4209* 0.1271***	1.2450 0.1645***	2.8280*** 1.4998***	3.2269*** 92.2546***	1.5372* 0.9544
PF10	0.5298 0.1490***	1.5371* 0.1606***	1.3751* 0.2078***	2.9258*** 1.8943***	3.2409*** 116.516***	1.7190** 1.2504
PF11	0.6525 0.1836***	1.6477* 0.1979***	1.4980* 0.2561***	3.0029*** 2.3351***	3.2515*** 143.63***	1.8753** 1.4859***
PF12	0.7706 0.2220***	1.7524** 0.2392***	1.6136* 0.3096***	3.0639*** 2.8224***	3.2598*** 173.6***	2.0098** 1.7959***
PF13	0.8840 0.2639***	1.8513** 0.2845***	1.7221** 0.3681***	3.1127*** 3.3560***	3.2665*** 206.43***	2.1259** 2.1355***
PF14	0.9926 0.3095***	1.9445** 0.3336***	1.8235** 0.4317***	3.1520*** 3.9361***	3.2720*** 242.1***	2.2266** 2.5046***
PF15	1.0962 0.3588***	2.0321** 0.3867***	1.9182** 0.5004***	3.1839*** 4.5625***	3.2765*** 280.64***	2.3143** 2.9033***

Note: Pn is the naïve portfolio. The upper (lower) value in each cell presents the estimate or the value of t test (F test). The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

4.3.1.2 Mean-variance (MV) criteria for individual assets and portfolios without wine

We turn to apply the MV criterion to compare the performance of the portfolios without wine and individual assets and exhibit the results in Tables 6C and 6D, respectively, for the case when short sale is not allowed and allowed.

From Table 6C, we find that by using the MV criterion, if we use 5% or 1% significant values, 1) investors prefer without-wine PF1-PF13 portfolios to SP500 (FTSE100) but indifference to PF14-PF15 and SP500 (FTSE100); 2) they prefer without-wine PF1-PF11 portfolios to Gold and there is no difference between PF12-PF14 and Gold but they prefer Gold to PF15; 3) they

prefer without-wine PF2-PF4 portfolios to House, but for higher risk they prefer House to without-wine PF6-PF15 portfolios; and 4) Bond dominates without-wine PF2-PF15 portfolios.

Table 6C: Mean-variance analysis of individual assets and portfolios without wine when short sale is not allowed

Without-wine	SP500	FTSE100	Gold	House	Bond	**Pn**
PF1	-0.6908 0.0012***	0.3485 0.0013***	0.0242 0.0017***	0.4840 0.0155	-0.0577 0.9542	-1.0237 0.0099***
PF2	-0.6400 0.0056***	0.3988 0.0060***	0.0822 0.0078***	0.6413 0.0713***	0.5601 4.3880***	-0.8688 0.0454***
PF3	-0.5866 0.0201***	0.4465 0.0217***	0.1389 0.0281***	0.7495 0.2558***	0.6554 15.7337***	-0.6935 0.1628***
PF4	-0.5313 0.0448***	0.4908 0.0483***	0.1932 0.0625***	0.8108 0.5698***	0.6765 35.049***	-0.5203 0.3626***
PF5	-0.4751 0.0797***	0.5314 0.0859***	0.2442 0.1112***	0.8400 1.0134	0.6839 62.3329***	-0.3640 0.6449***
PF6	-0.4190 0.1248***	0.5681 0.1345***	0.2914 0.1740***	0.8506 1.5865***	0.6872 97.5861***	-0.2303 1.0096
PF7	-0.3636 0.1800***	0.6006 0.1940***	0.3344 0.2511***	0.8514 2.2892***	0.6889 140.8066***	-0.1187 1.4567***
PF8	-0.3097 0.2455***	0.6292 0.2646***	0.3732 0.3424***	0.8473 3.1214***	0.6899 191.9956***	-0.0264 1.9862***
PF9	-0.2577 0.3211***	0.6540 0.3461***	0.4078 0.4479***	0.8410 4.0832***	0.6906 251.1532***	0.0499 2.5982***
PF10	-0.2081 0.4069***	0.6754 0.4386***	0.4385 0.5676***	0.8339 5.1745***	0.6910 318.2793***	0.1135 3.2927***
PF11	-0.1611	0.6936	0.4656	0.8267	0.6912	0.1669

	0.5029***	0.5421***	0.7015***	6.3954***	393.374***	4.0695***
PF12	-0.1168 0.6091***	0.7091 0.6565***	0.4894 0.8496*	0.8198 7.7458***	0.6914 476.4374***	0.2120 4.9289***
PF13	-0.0752 0.7255***	0.7220 0.7820***	0.5104 1.0119	0.8132 9.2258***	0.6916 567.472***	0.2505 5.8706***
PF14	-0.0363 0.8537	0.7326 0.9201*	0.5285 1.1907	0.8064 10.855***	0.6910 667.699***	0.2834 6.9075***
PF15	0.0000 1.0000	0.7398 1.0778	0.5432 1.3948***	0.7972 12.716***	0.6879 782.1458***	0.3109 8.0915***

Note: Pn is the naïve portfolio. The upper (lower) value in each cell presents the estimate or the value of t test (F test). The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

On the other hand, when short sale is allowed, if we use 5% or 1% significant value, from Table 6D we find that 1) investors prefer without-wine PF1-PF15 portfolios to SP500, FTSE100 and Gold; 2) they prefer without-wine PF1-PF9 portfolios to House and there is no difference between PF10-PF15; and 3) prefer Bond to without-wine PF2-PF6 portfolios but are indifferent between without-wine PF1, PF7-PF15 portfolios and Bond.

Table 6D: Mean-variance analysis of individual assets and portfolios without wine when short sale is allowed

Without-wine	SP500	FTSE100	Gold	House	Bond	**Pn**
PF1	-0.6918 0.0012***	0.3475 0.0013***	0.0230 0.0017***	0.4804 0.0154***	-0.0780 0.9488	-1.0266 0.0098***
PF2	-0.6421 0.0020***	0.3986 0.0021***	0.0813 0.0028***	0.6522 0.0254***	0.7962 1.5601***	-0.8838 0.0161***
PF3	-0.5920 0.0043***	0.4493 0.0047***	0.1394 0.0061***	0.8146 0.0552***	1.2674 3.3940***	-0.7375 0.0351***

PF4	-0.5417 0.0082***	0.4995 0.0089***	0.1971 0.0115***	0.9638 0.1049***	1.4799* 6.4506***	-0.5903 0.0667***
PF5	-0.4911 0.0137***	0.5490 0.0148***	0.2542 0.0191***	1.0975 0.1744***	1.5832* 10.7298***	-0.4450 0.1110***
PF6	-0.4404 0.0208***	0.5977 0.0224***	0.3105 0.0289***	1.2148 0.2639***	1.6393* 16.2316***	-0.3038 0.1679***
PF7	-0.3899 0.0294***	0.6456 0.0316***	0.3660 0.0409***	1.3159* 0.3732***	1.6729** 22.9561***	-0.1687 0.2375***
PF8	-0.3395 0.0395***	0.6925 0.0426***	0.4204 0.0551***	1.4019* 0.5024***	1.6944** 30.9032***	-0.0410 0.3197***
PF9	-0.2893 0.0512***	0.7383 0.0552***	0.4735 0.0715***	1.4743* 0.6515***	1.7091** 40.0729***	0.0787 0.4146***
PF10	-0.2396 0.0645***	0.7829 0.0695***	0.5254 0.0900***	1.5349* 0.8205*	1.7196** 50.4653***	0.1898 0.5221***
PF11	-0.1904 0.0794***	0.8264 0.0855***	0.5759 0.1107***	1.5854* 1.0093	1.7273** 62.0802***	0.2925 0.6422***
PF12	-0.1417 0.0958***	0.8686 0.1032***	0.6249 0.1336***	1.6273* 1.2180*	1.7332** 74.9178***	0.3869 0.7750**
PF13	-0.0937 0.1138***	0.9096 0.1226***	0.6724 0.1587***	1.6622** 1.4466***	1.7378** 88.9781***	0.4735 0.9205
PF14	-0.0464 0.1333***	0.9491 0.1437***	0.7182 0.1859***	1.6911** 1.6950***	1.7415** 104.2609***	0.5527 1.0786
PF15	0.0000 0.1544***	0.9874 0.1664***	0.7624 0.2154***	1.7151** 1.9634***	1.7445** 120.7664***	0.6251 1.2494**

Note: Pn is the naïve portfolio. The upper (lower) value in each cell presents the estimate or the value of t test (F test). The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

4.3.2 Stochastic dominance (SD) criteria for individual assets and portfolios with and without wine

Since the Jarque-Bera (JB) statistic shows that the distributions of the returns for the portfolios are not normal distributed, suggesting that the conclusion drawn from the mean-variance analysis may be misleading. Thus, we turn to apply the SD test to examine the preference of portfolios with and without wine and individual assets.

4.3.2.1 Stochastic dominance (SD) criteria for individual assets and portfolios with wine

We first discuss the SD test to examine the preference of portfolios with wine and individual assets and display the results in Tables 7A and 7B, respectively, when short sale is not allowed and is allowed.

From Table 7A, when short sale is not allowed, we compare the with-wine portfolios and individual assets and conclude the following 1) with-wine PF1-PF15 portfolios dominate SP500, FTSE100, and Gold in the sense of both second and third order; 2) with-wine PF1-PF6 and PF8-PF9 portfolios second- and third-order dominate House, 3) With-wine PF7 and PF10-PF13 portfolios first-order dominate House, 4) there is no difference between with-wine PF14-PF15 portfolios and House; and 5) there is no difference between with-wine PF1 and PF3-PF15 portfolios and Bond. 6) However, Bond dominates with-wine PF2 portfolio in the sense of the second and third order.

Table 7A: Stochastic dominance analysis of individual assets and portfolios with wine when short sale is not allowed

With wine	SP500	FTSE100	Gold	House	Bond	Pn
PF1	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	=	$\succ_{2,3}$

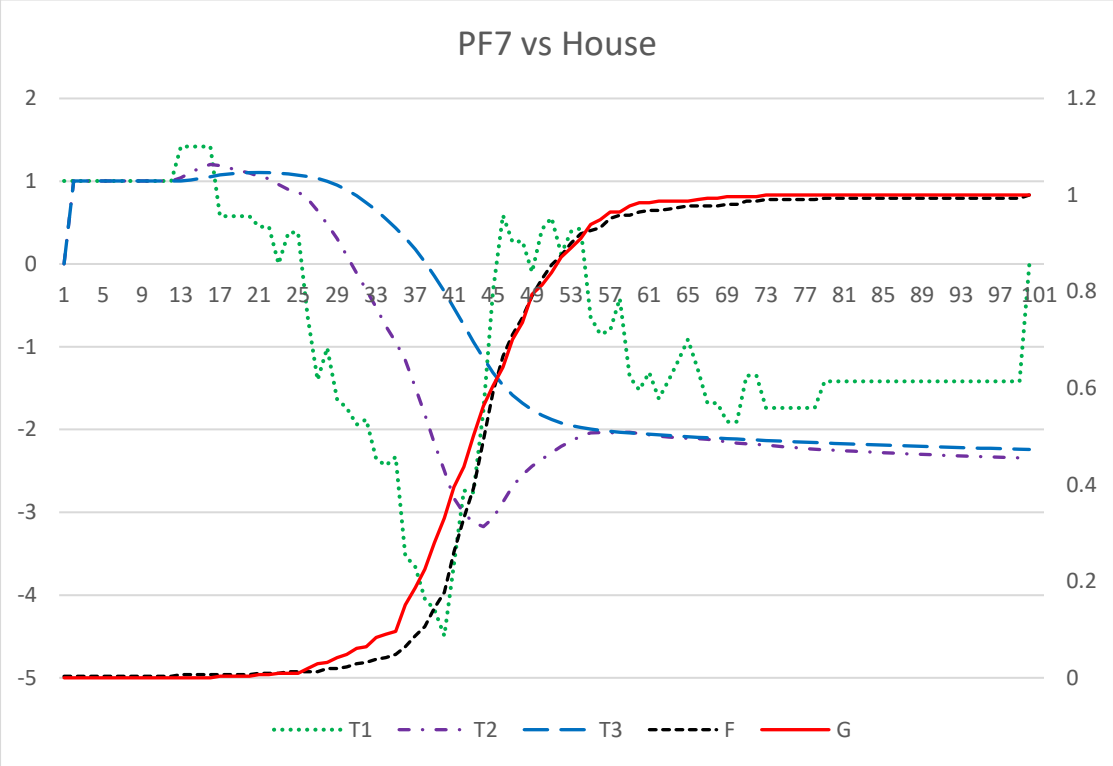
PF2	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF3	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF4	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF5	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF6	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF7	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$\succ_{2,3}$
PF8	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$
PF9	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$
PF10	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$=$
PF11	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$=$
PF12	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$=$
PF13	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$=$
PF14	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$	$=$
PF15	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$	$=$
Pn	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	

Note: This table reports the stochastic-dominance (SD) results to test whether with-wine portfolios strictly dominate any of the individual assets being studied in this paper and the naïve portfolio Pn when short sale is not allowed at the *j*-order stochastic dominance for *j* = 1, 2, 3. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{1,2,3}$ is defined in (2), and = means "is indifferent from". For example, the second cell in the second row of the table infers that the with-wine portfolio PF1 strictly dominate S&P500 at the second- and third-order stochastic dominance while the sixth cell in the second row of the table infers that the with-wine portfolio PF1 is indifferent from Bond when short sale is not allowed. The rest of the cells can be read in a similar way. Portfolios PF1 to PF15 and the naïve portfolio Pn are defined in Section 4.2.1.

To illustrate the first order dominance, we plot the CDFs of the with-wine PF7 portfolio and House in Figure 2. From the figure, we find that with-wine PF7 portfolio dominates House in nearly the entire distribution with some highly significant while House dominates with-wine PF7 portfolio only in very small region and their CDFs is nearly coincide, implying that for the region House dominates with-wine PF7 portfolio is not significant, and thus, we have the with-wine PF7 portfolio first-order dominates House which, in turn, implies that there exists

expected arbitrage opportunity (Sriboonchitta, et al., 2009; Guo, et al., 2017) between PF7 (and others) with House.

Figure 2: CDF and SD Statistics for with-wine PF7 Portfolio and House



Note: *F* and *G* denoting the CDFs of with-wine PF7 Portfolio and House, respectively.

Table 7B: Stochastic dominance analysis of individual assets and portfolios with wine when short sale is allowed

With wine	SP500	FTSE100	Gold	House	Bond	Pn
PF1	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF2	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF3	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF4	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF5	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF6	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$\succ_{2,3}$

PF7	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$\succ_{2,3}$
PF8	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF9	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF10	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$\succ_{2,3}$
PF11	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$\succ_{2,3}$
PF12	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{1,2,3}$	$=$	$=$
PF13	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$	$=$
PF14	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$	$=$
PF15	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$=$	$=$
Pn	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	

Note: This table reports the stochastic-dominance (SD) results to test whether with-wine portfolios strictly dominate any of the individual assets being studied in this paper and the naïve portfolio Pn when short sale is allowed at the *j*-order stochastic dominance for *j* = 1, 2, 3. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{1,2,3}$ is defined in (2), and = means "is indifferent from". For example, the second cell in the second row of the table infers that the with-wine portfolio PF1 strictly dominate S&P500 at the second- and third-order stochastic dominance while the sixth cell in the second row of the table infers that the with-wine portfolio PF1 is indifferent from Bond when short sale is allowed. The rest of the cells can be read in a similar way. Portfolios PF1 to PF15 and the naïve portfolio Pn are defined in Section 4.2.1.

The SD results are exhibited in Table 7B when short sale is allowed. From Table 7B, we conclude the SD results when short sale is allowed are similar to those when short sale is not allowed. We summarize it here: when short sale is allowed, using SD approach, we conclude the following: 1) all with-wine PF1-PF15 portfolios dominate SP500, FTSE100, and Gold in the sense of both second and third order; 2) except very high risk with-wine portfolios (i.e. PF13 to PF15), all with-wine portfolios dominate House, 3) many with-wine (PF6, PF7 and PF10-PF12) portfolios first-order dominate House, and 4) except PF2, there is no difference between with-wine portfolios and Bond. In addition, the SD results when short sale is allowed are similar to those when short sale is not allowed.

4.3.2.2 Stochastic dominance (SD) criteria for individual assets and portfolios without wine

We now compare the portfolios without wine and individual assets when short sale is allowed and is not allowed, and list the SD results in Tables 7C and 7D, respectively. When short sale is not allowed, we find that 1) without-wine PF1-PF11 portfolios dominate both SP500 and FTSE 100; 2) without-wine PF1-PF10 portfolios second- and third-order dominate Gold; 3) without-wine PF1-PF4 portfolios second- and third-order dominate House; 4) Bond second- and third-order dominates without-wine PF2-PF15 portfolios; 5) for higher risk, House second- and third-order dominates without-wine PF7-PF15 portfolios; and 6) there is no difference between any of the without-wine PF12-PF15 portfolios and any of SP 500 and FTSE 100, between any of the without-wine PF11-PF15 portfolios and Gold, between any of the without-wine PF5-PF6 portfolios and House, and between without-wine PF1 portfolio and Bond.

Table 7C: Stochastic dominance analysis of individual assets and portfolios without wine when short sale is not allowed

Without wine	SP500	FTSE100	Gold	House	Bond	Pn
PF1	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF2	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF3	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF4	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF5	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$
PF6	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$
PF7	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$	$=$
PF8	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF9	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF10	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF11	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF12	$=$	$=$	$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$

PF13	$=$	$=$	$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF14	$=$	$=$	$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
PF15	$=$	$=$	$=$	$\prec_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$
Pn	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	

Note: This table reports the stochastic-dominance (SD) results to test whether without-wine portfolios strictly dominate any of the individual assets being studied in this paper and the naïve portfolio Pn when short sale is not allowed at the *j*-order stochastic dominance for j = 1, 2, 3. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{1,2,3}$ is defined in (2), and = means "is indifferent from". For example, the second cell in the second row of the table infers that the without-wine portfolio PF1 strictly dominate S&P500 at the second- and third-order stochastic dominance while the sixth cell in the second row of the table infers that the with-wine portfolio PF1 is indifferent from Bond when short sale is not allowed. The rest of the cells can be read in a similar way. Portfolios PF1 to PF15 and the naïve portfolio Pn are defined in Section 4.2.1.

Table 7D: Stochastic dominance analysis of individual assets and portfolios without wine when short sale is allowed

Without wine	SP500	FTSE100	Gold	House	Bond	Pn
PF1	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\succ_{2,3}$
PF2	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF3	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF4	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF5	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF6	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF7	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF8	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF9	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF10	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\succ_{2,3}$
PF11	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$
PF12	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$
PF13	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$

PF14	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	$=$
PF15	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$\prec_{2,3}$	$\prec_{2,3}$	$=$
Pn	$\succ_{2,3}$	$\succ_{2,3}$	$\succ_{2,3}$	$=$	$\prec_{2,3}$	

Note: This table reports the stochastic-dominance (SD) results to test whether without-wine portfolios strictly dominate any of the individual assets being studied in this paper and the naïve portfolio Pn when short sale is allowed at the *j*-order stochastic dominance for *j* = 1, 2, 3. The value in each cell presents the value of the SD test defined in (3) with H_0, H_A, H_{A1}, and H_{A2} defined in (4), $\succ_{1,2,3}$ is defined in (2), and = means "is indifferent from". For example, the second cell in the second row of the table infers that the without-wine portfolio PF1 strictly dominate S&P500 at the second- and third-order stochastic dominance while the sixth cell in the second row of the table infers that the with-wine portfolio PF1 is indifferent from Bond when short sale is allowed. The rest of the cells can be read in a similar way. Portfolios PF1 to PF15 and the naïve portfolio Pn are defined in Section 4.2.1.

From Table 7D, when short sale is allowed, we compare the portfolios without wine and individual assets and obtain the following observations: 1) without-wine PF1-PF15 portfolios second- and third-order dominate SP500, FTSE100, and Gold; 2) without-wine PF1-PF10 portfolios second- and third-order dominate House, 3) Bond second- and third-order dominates without-wine PF2-PF15 portfolios; 4) House second- and third-order dominates without-wine PF15 portfolio; there is no difference between any of the without-wine PF11-PF14 portfolios and House, and between PF1 and Bond.

In short, comparing the performance between with-wine portfolios and individual assets and between without-wine portfolios and individual assets by using both MV and SD approaches, we find that, in general, with-wine portfolios either dominate individual assets or indifferent from individual assets while some without-wine portfolios dominate some individual assets, indifferent from other individual assets, and are dominated by some other individual assets, especially Bond that dominates most of the without-wine portfolios. Thus, we conclude that Wine contributes significantly in the portfolios to make with-wine portfolios either prefer individual assets or indifferent from individual assets and eliminate the situation that individual assets dominate portfolios as in the without-wine portfolios. In addition, this paper observes a very important result: there exist some cases in which the with-wine portfolios first-order SD

(FSD) dominate House in both long-only and short-allowed strategies. This observation does not happen in any of the without-wine portfolios. This implies that the market is not efficient and there exist expected arbitrage opportunity (Guo, et al., 2017) when investors include Wine in their investment.

4.4 Preference for individual assets and the equal-weighted portfolio

Academics have been comparing the preference between the portfolios in the frontier and the naive equal-weighted portfolio, see, for example, Hoang, et al. (2015) and the references therein for more information. However, it is also interesting to compare the preference between the naive equal-weighted portfolio and individual assets. Thus, in this paper, we compare the preference between the naive equal-weighted portfolio (De Miguel et al., 2009) and individual assets, especially Wine in this section.

4.4.1 Mean-variance (MV) criteria for individual assets and the equal-weighted portfolio

Table 8A: Mean-variance analysis of individual assets and the equal-weighted portfolio

	Mean	s.d.	t test	F test
Wine	0.0087***	0.0311	1.9712**	4.3804***
SP500	0.0056**	0.0422	0.3109	8.0915***
FTSE100	0.0031	0.0407	-0.6803	7.5073***
Gold	0.0039*	0.0357	-0.4168	5.8014***
House	0.0036***	0.0118	-1.1083	0.6363
Bond	0.0040***	0.0015	-1.0153	0.0103***
Pn	0.0048***	0.0148		

Note: Pn is the naïve portfolio. The value in the cell of t test (F test) is the value of t test (F test) between each individual asset and the naïve portfolio. The symbols *, **, and *** denote the significance at the 10%, 5%, and 1% levels, respectively.

We list the MV table of individual assets and the equal-weighted portfolio in Table 8A. If one employs the MV criterion for investors to compare their preferences between individual assets and the equal-weighted portfolio, one will find that there is no difference between Wine (House) and the naïve portfolio, investors prefer the naïve portfolio to SP 500, FTSE 100 and Gold, but prefer Bond to the naïve portfolio.

4.4.2 Stochastic dominance (SD) criteria for individual assets and the equal-weighted portfolio

Table 8B: Stochastic dominance analysis of individual assets and the equal-weighted portfolio

	Dominant Relationship	
Wine	$=$	Pn
SP500	$\prec_{2,3}$	Pn
FTSE100	$\prec_{2,3}$	Pn
Gold	$\prec_{2,3}$	Pn
House	$=$	Pn
Bond	$\succ_{2,3}$	Pn

We present the SD results between the individual assets and the naïve portfolio in Table 8B. From the table, we find that we obtain the same conclusion with the MV criterion. That is, 1) there is no difference between Wine (House) and the naïve portfolio; 2) investors prefer the naïve portfolio to SP 500, FTSE 100 and Gold; 3) but they prefer Bond to the naïve portfolio.

Both MV and SD results imply that risk averters could prefer the naïve portfolio to some individual assets, but, on the other hand, it could be indifferent from some individual assets while risk averters could prefer some other individual assets to the naïve portfolio. However, there is no different between Wine and the naïve portfolio. Thus, Wine is a good choice in

the investment in the sense that the naïve portfolio could dominate other individual assets, but cannot dominate Wine.

4.5 Preference for portfolios with and without Wine and the equal-weighted portfolio

Academics are interested in comparing the preference of the portfolios in the frontier and the naive equal-weighted portfolio since Markowitz (1952) and others derive the frontiers of assets. Some believe that the portfolios in the frontier is better while others, for example, (De Miguel et al. (2009) argue that the naive equal-weighted portfolio is better. In this section, we conduct analysis to compare the performance between the portfolio with and without Wine and the naive equal-weighted portfolio. We first apply both MV criteria and the SD test to compare the performance between portfolios with and without Wine and the equal-weighted portfolio

4.5.1 Mean-variance (MV) criteria for portfolios with and without Wine and the equal-weighted portfolio

We first apply the MV criteria to compare preference between portfolios with and without Wine and the equal-weighted portfolio for two different strategies: long only and short sale is allowed.

4.5.1.1 Mean-variance (MV) criteria for portfolios with Wine and the equal-weighted portfolio for long-only strategy

We now apply the MV criteria to compare the performance between portfolios with Wine and the equal-weighted portfolio for the long-only strategy and exhibit the results in Table 4A. Our results on the mean-variance criterion suggest that investors prefer any of the with-wine PF1-PF7 portfolios to the equal-weighted portfolio, since the former provides significant lower risk, but investors are indifferent between the with-wine PF8-PF16 portfolios and the naïve portfolio for long-only strategy.

4.5.1.2 Mean-variance (MV) criteria for portfolios with Wine and the equal-weighted portfolio for short-allowed strategy

We now apply the MV criteria to compare the performance between portfolios with Wine and the equal-weighted portfolio for the short-allowed strategy and exhibit the results in Table 4B. From the table, we find that investors prefer any of the with-wine PF1-PF9 portfolios to the equal-weighted portfolio, but there is no difference between with-wine PF10-PF15 portfolios and the naïve portfolio.

4.5.1.3 Mean-variance (MV) criteria for portfolios without Wine and the equal-weighted portfolio for long-only strategy

For comparison, we apply the MV criteria to compare the performance between portfolios without Wine and the equal-weighted portfolio for the long-only strategy and exhibit the results in Table 4A. From the table, we find that investors prefer any of the without-wine PF1-PF5 portfolios to Pn and there is no difference between without-wine PF6 portfolio and Pn, but they prefer Pn to any of the without-wine PF7-PF15 portfolios for the long-only strategy.

4.5.1.4 Mean-variance (MV) criteria for portfolios without Wine and the equal-weighted portfolio for short-allowed strategy

Last, we turn to apply the MV criteria to compare the performance between portfolios without Wine and the equal-weighted portfolio for the short-allowed strategy and exhibit the results in Table 4B. From the table, we find that investors prefer any of the without-wine PF1-PF12 portfolios to Pn, there is no difference between any of the without-wine PF13-PF14 portfolios and Pn, but prefer the without-wine PF15 portfolio to Pn.

In summary, when we apply the mean-variance criterion to compare investors' preference between with-wine (without-wine) portfolios to the equal-weighted portfolio, we find that investors prefer low-risk with-wine portfolios to the equal-weighted portfolio, they are indifferent between the high-risk with-wine portfolios and the naïve portfolio for both long-only and short-allowed strategies. However, investors prefer low-risk without-wine portfolios to the naïve portfolio, there is no difference between medium-risk without-wine portfolio and the naïve portfolio, but they prefer the naïve portfolio to high-risk without-wine portfolios for both long-only and short-allowed strategies. Thus, Wine is very important in the portfolio investment in the sense that investors will never prefer the naïve portfolio to any of the with-wine portfolios but they do for some high-risk without-wine portfolios for both long-only and short-allowed strategies.

4.5.2 Stochastic dominance (SD) criteria for portfolios with and without Wine and without and the equal-weighted portfolio

Since the Jarque-Bera (JB) statistic shows that the distributions of the returns for the portfolios are not normal distributed, suggesting that the conclusion drawn from the mean-variance analysis may be misleading. Thus, we turn to apply the SD test to compare the performance between portfolios with and without Wine and the equal-weighted portfolio for two different strategies: long only and short sale is allowed.

4.5.2.1 Stochastic dominance (SD) criteria for portfolios with Wine and the equal-weighted portfolio

We now apply the SD test to compare the performance between portfolios with Wine and the equal-weighted portfolio for both long-only and short-allowed strategies and exhibit the results in Tables 7A and 7B, respectively. From the tables, we find that the SD results are consistent with the results obtained by using the mean-variance criterion but get more information. When

short sale is not allowed, our SD results suggest that investors would prefer any of the with-wine PF1-PF7 portfolios to the equal-weighted portfolio, and indifferent between any of the with-wine PF8-PF16 portfolios and the naïve portfolio. On the other hand, when short sale is allowed, by using the SD test, we find that investors would prefer any of the with-wine PF1-PF9 portfolios to the equal-weighted portfolio and indifferent between any of the with-wine PF10-PF15 portfolios and the naïve portfolio.

4.5.2.2 Stochastic dominance (SD) criteria for portfolios without Wine and the equal-weighted portfolio (long only+ short allowed)

For comparison, we apply the SD test to compare the performance between portfolios without Wine and the equal-weighted portfolio for both long-only and short-allowed strategies and exhibit the results in Tables 7C and 7D, respectively. From the tables, we find that the SD results are basically consistent with the MV results but provide more information. When short sale is not allowed, we find that 1) investors prefer any of the without-wine PF1-PF4 portfolios to Pn; 2) they are indifferent between any of the without-wine PF5-PF7 portfolios and the equal-weighted portfolio; 3) for higher-risk portfolio, the naïve portfolio Pn dominates any of the without-wine PF8-PF15 portfolios at the second and third order. On the other hand, when short sale is allowed, we find that investors prefer any of the without-wine PF1-PF10 portfolios to the equal weighted portfolio Pn, but they are indifferent between any of the without-wine PF11-PF15 portfolios and Pn.

In summary, when we apply both mean-variance criterion and SD test to compare investors' preference between with-wine (without-wine) portfolios to the equal-weighted portfolio, we find that the second- and third-order risk averters prefer any of the low-risk with-wine portfolios to the equal-weighted portfolio, but are indifferent between any of the high-risk with-wine portfolios and the naïve portfolio for both long-only and short-allowed strategies. However, the second and third-order risk averters prefer any of the low-risk without-wine

portfolios to the naïve portfolio, there is no difference between any of the medium-risk without-wine portfolio and the naïve portfolio, but prefer the naïve portfolio to any of the high-risk without-wine portfolios for both long-only and short-allowed strategies. Thus, Wine is very important in the portfolio investment in the sense that investors will never prefer the naïve portfolio to any with-wine portfolios but they do for some high-risk without-wine portfolios for both long-only and short-allowed strategies.

5. Inferences and concluding Remarks

In this paper, we apply both MV rule and SD test to examine whether Wine is a better choice in the investment decision for risk-averse investors. To check whether Wine is a better choice, we compare the performance in the following aspects: (a) among different individual assets including US/UK stocks, bonds, gold, house and Wine, (b) between portfolios in the frontiers with and without wine, (c) between with-wine (without-wine) portfolios in the frontier and individual assets, (d) between different individual assets and and the naive equal-weighted portfolio, and (e) between the portfolios in the frontiers and the naive equal-weighted portfolio.

For (a), our MV and SD analyses suggest that wine is the best investment among US/UK stocks, bonds, gold, housing prices and wine. For (b), from visual examination on the figures, it is obvious from the modern finance theory that portfolios with wine are more profitable than those without wine, regardless whether short sale is allowed or not because the efficient frontiers with wine are on top of those without wine for both long-only and short sale allowed strategies. Nonetheless, when we apply the formal MV and SD tests, we find that, in general, the traditional financial theory is correct that the second- and third-order risk averters prefer to invest in with-wine portfolios than without-wine portfolios when short sale is not allowed. However, investors are indifferent between portfolios with and without wine when short sale is allowed. This shows that the visual conclusion may not always hold true.

For (c), our analysis obtains two interesting results. First, we find that, in general, with-wine portfolios either dominate individual assets or indifferent from individual assets while some without-wine portfolios dominate some individual assets, indifferent from other individual assets, and are dominated by some other individual assets, especially Bond that dominates most of the without-wine portfolios. Thus, we conclude that Wine contributes significantly in the portfolios to make with-wine portfolios either prefer individual assets or indifferent from individual assets and eliminate the situation that individual assets dominate portfolios as in the without-wine portfolios. Second, our analysis discovers a very important result: there exist some cases in which the with-wine portfolios first-order SD (FSD) dominate housing prices in both long-only and short-allowed strategies. This observation does not happen in any of the without-wine portfolios. This implies that the market is not efficient and there exist expected arbitrage opportunity when investors include Wine in their investment.

For (d), our analysis imply that risk averters could prefer the naïve portfolio to some individual assets, but, on the other hand, it could be indifferent from some individual assets while risk averters could prefer some other individual assets to the naïve portfolio. However, there is no different between Wine and the naïve portfolio. Thus, Wine is a good choice in the investment in the sense that the naïve portfolio could dominate other individual assets, but cannot dominate wine.

For (e), we find that the second- and third-order risk averters prefer any of the low-risk with-wine portfolios to the equal-weighted portfolio, but are indifferent between any of the high-risk with-wine portfolios and the naïve portfolio for both long-only and short-allowed strategies. However, the second and third-order risk averters prefer any of the low-risk without-wine portfolios to the naïve portfolio, there is no difference between any of the medium-risk without-wine portfolio and the naïve portfolio, but prefer the naïve portfolio to any of the high-risk without-wine portfolios for both long-only and short-allowed strategies. Thus, wine is very important in the portfolio investment in the sense that investors will never prefer the naïve

portfolio to any with-wine portfolios but they do for some high-risk without-wine portfolios for both long-only and short-allowed strategies.

Our findings are partially in line with Fogarty (2007, 2010), Masset and Weisskop (2010), Bouri (2015), Jureviciene and Jakavonyte (2016), and Aytaç et al. (2016) who show the benefits of adding wine to a standard portfolio of stocks and bonds through the analysis of risk and return. Our analysis provides additional information and observations that the literature has not explored beforehand. Especially, our findings nicely complement that of Masset and Henderson (2010), which highlight the risk-reduction benefits of wine investment and focus on optimal portfolios based on the four moments of the return distribution.

In addition to extending our understanding on the role of wine investment within a portfolio of different assets, our findings are useful for making investment decisions. Specifically, they help investors optimize their decision making using full information rather than just the first and second moments. Importantly, our findings point toward that wine market investment is not efficient in the sense that it is possible to earn abnormal returns from the investment in wine via an arbitrage, a first in the wine literature.

While we have relied on a leading (monthly) benchmark for wine prices - the Liv-ex Fine Wine Investables - Masset and Weisskopf (2017) point to the possibility that the use of existing wine indices, including the daily Liv-ex 50, would inflate the diversification potential of fine wines because of the relatively less liquidity of wine investment as compared to conventional assets. Further studies should address this issue with daily data within a SD-based approach.

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