Is wine a premier cru investment?

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We investigate the case for Bordeaux and Rhone wine as an investment. The raw data analysed comprises of approx. 335,000 observations of wine sales prices and is analysed using the repeat sales regression method. General Red Bordeaux and Rhone wine indices are constructed for the period January 1996 – January 2007, which are compared with each other , with the Dow Jones Industrial Average (DJIA), and with a number of wine funds and finally with the the Liv-Ex Fine Wine 100 (FW100) Index. The findings suggest that Rhone and Bordeaux wines can provide average returns in excess of risk-free investments with lower risk at index level. Individual wines and sub-regions carry higher risk than the general indices with varying return levels and so direct investment in such wine by inexperienced, low volume or individual investors carries a high level of risk. Returns on indirect investment via wine funds vary, however all average returns of funds analysed exceed the general Rhone and Bordeaux Index in this research. Volatility for some wine funds was particularly high and may not suit risk-averse investors.

1. INTRODUCTION

In the wake of the global financial crisis of 2008, which saw financial institutions with asset values greater than the GDP of many countries file for bankruptcy (Areppim, 2008), investors are seeking new asset classes to diversify the risk in their portfolios. The market crash of 2008 wiped unprecedented value from equities, bonds and other asset classes across almost all major stock markets. Already, economists are predicting when the next crash will happen, even suggesting that the success of emerging economies such as China may be a bubble (Ovide, S., 2011). It is not surprising; therefore, that many investors are deflecting from traditional equity and fixed income products that performed poorly at times of crisis. Alternative investments now present a very real opportunity for individual and institutional investors alike to make healthy returns in the hope that they do not follow the market in the same way as equities and bonds. One investment area of particular interest is the case for wine as an investment.

Wine is not an obvious investment vehicle, as it does not behave like a traditional investment in physical terms. Firstly, wine is a tangible, consumable asset that must be stored and cared for after purchase. It cannot be delivered electronically like many common stocks, derivatives and bonds. Generally speaking, a case of wine does not pay a dividend or a coupon before the asset is sold as investment grade wine is mostly sold at auction. Additionally, the value of wine to the purchaser is derived from either the utility of consumption or the difference between the purchase price and the sales price minus related costs. However, monthly auction turnover and the trading frequency of many wines make the asset attractive as an investment instrument. (Sanning et. Al., 2007).

There have been documented cases where wine earned an average return of up to 70% per annum over a period of six years (Masset, P. and Weisskopf, J., 2010). Whilst returns as high as this are unusual and not limited to wine, there is further evidence of strong financial performance of wine investment vehicles. The Wine Investment Fund (TWIF) invests in fine wines worldwide which are stored in the U.K. with the aim of maximising returns for investors. The fund invests in tranches of wines with an investment term of five years and a minimum investment of £10,000 GBP. The fund performance was analysed in order to assess an example of the case for wine investment (TWIF, 2010). TWIF generates a higher average annual return per tranche than the Dow Jones Industrial Average (DJIA) for the period since the fund's inception (13.62% vs. 5.82%), however the DJIA had a much higher variance than TWIF (18.16% vs. 4.79%). It must also be noted that there are more TWIF investment tranches per year than DJIA year-end return observations, which distorts results somewhat. Despite this, however, TWIF emerges as a fund with strong returns across the period 2003-2010, with low volatility relative to the DJIA and hence lower risk. By contrast, the DJIA has a

much larger variance and risk, of which the GFC was a large contributor. In total, out of 20 tranches of TWIF, the majority (55%) outperformed the corresponding DJIA annual return.

The case of TWIF shows the potential benefits of investing in wine and specifically the potential of wine to generate returns stronger than equity indices with lower levels of risk. There has been some research in the past into specific wines as an investment, with most researchers constructing indices at a regional or multiple-region level. Some wines, such as Red Bordeaux wines, trade particularly frequently at auction and are ideal for analysis. This trading frequency is particularly apparent in the data from The Chicago Wine Company (TCWC) auction house, with the majority of wines traded originating in this region. Red Bordeaux wines have shown promising returns in the past with studies analysing general returns to this wine category (Sanning et. al, 2001). It was found that other French wines are of particular interest to wine investors and research has shown their returns to be attractive also. This paper examines Red Bordeaux and Rhone wines both of which performed strongly in recent times (Masset & Weisskopf, 2010) and which the most frequently traded wines regions with TCWC.

2. REVIEW OF RELEVANT LITERATURE

Studies of the return that wine as an asset class generates have been far from in agreement. Krasker (1979) tests the consensus belief of experts at the time that purchasing and holding wine gives "very large" returns and concludes that this belief is false. The study even goes as far as to say that wine yields returns no larger than that of holding low-yield "risk free" US Treasury Bills (T-bills). Subsequently, Jaeger (1981) extends and reinterprets Krasker's study using a much larger dataset and produces contradictory results. Jaeger's results show that wine does carry a risk premium over other asset classes and generates positive returns in excess of T-bills. Jaeger's contradiction of Krasker focuses on two main points, the storage cost estimate used in his analysis and the limited dataset used by Krasker.

Burton and Jacobsen (2001) apply the repeat sales regression method to monthly auction hammer price data. They note that wine can behave like art and other collectibles that embody some form of user benefit, unlike traditional financial assets. Additionally, wine should command a premium over other investments due to the costs associated with holding the investment and the less "liquid" nature of the market. At the time of the study there were 90 wine auctions of significance per year and the costs associated with them are high. The overall conclusion of Burton and Jacobsen's study is that wine is "only questionably a profitable investment instrument". Whilst the wine index constructed and the semi-annual return rates computed by Burton and Jacobsen

yield decent returns relative to equity (8% nominal p.a. from 1986-1996), the additional risk incurred by the asset class does not make the asset class attractive as an investment.

Sanning et. al (2007) analyse the attributes and financial performance of Red Bordeaux wine as an investment between 1996 and 2003. Like the previous studies mentioned auction hammer price data is used in the analysis, however a different model approach is taken, with the wine price being modelled as a combination of the Fama-French Three Factor Model (FFM) and the Capital Asset Pricing Model (CAPM). The study conclusions are positive, in line with that of Jaeger and contradictory to those of Krasker and Burton & Jacobsen. The analysis reveals Red Bordeaux wines yield positive returns in excess of those predicted by commonly accepted factors explaining the variation in stock price return. The annual returns estimated by the study are between 7.5% and 9.5% in excess of those predicted by factors shown to account for risk. Furthermore, Sanning et. al claim to show that wines have "effectively zero betas" and hence low exposure to market risk. This claim is perhaps the strongest argument for wine as an investment as if true then it represents a natural hedge in a portfolio that is heavy in positive-beta assets, as are most stocks and bonds.

Masset and Weisskopf (2010) analysed the investment performance of wine over a longer period than Sanning et. al, from 1996-2009 using the same methodology as Burton & Jacobsen (2001), the repeat sales regression and extending the study with the CAPM. A General Wine Index and a First Growth Wine Index are constructed and compared to the Russell 3000. Both wine indices outperform the Russell 3000 with the First Growth index significantly outperforming both the Russell and the General Wine Index, especially from 2005 - early 2008. However, both wine indices incurred substantial losses in line with other financial assets (~17%) since mid 2008, indicating that wine was susceptible to the financial crisis. This contradicts Sanning et. al's key assertion that wine is effectively a zero-beta asset and undermines one of the key arguments for wine investment – its hedging effect

When considering wine as an investment, it is essential to realise the overlap in the behaviour of wine and other collectibles such as art that are not necessarily desirable as more traditional financial assets. Burton and Jacobsen (2001) argue that excepting the utility an investor may get from an artistic piece, many studies have shown the inflation-adjusted return on this asset class to be poor, at a maximum of 1.6% annually between 1950 and 1987 and as low as 0.55% in the 250+ years preceding 1961. Since wine can be valued as a collector's item, analysis must consider the possibility that wine may produce similarly poor returns. Burton and Jacobsen test the assertion that wine is an exception to this rule and their research concludes that this assertion appears to hold. As noted above, poor art returns are likely explained by the consumption value of the asset that cannot be taken into account using sales values. Indeed, Campbell et. Al (2009) even assert that

the consumption value of emotional assets like art represents an income stream. The fact that wine appears to be an exception to this rule is explained by the fact that the consumption utility of wine is generally consumed from physical consumption, a one-time occurrence, whereas art can be consumed continuously. By contrast, Delorme et. al (1994) remark that all collectibles share a common pattern of low returns and high volatility.

3. DATA & METHODOLOGY

a. Data

The data for this paper are the hammer prices of clean bottles of the wines most frequently traded with TCWC from the Bordeaux (red wine only) and Rhone regions. Frequently traded wines are defined as any wine from these regions for which there are at least 200 sales observations. From approx. 355,000 observations in the TCWC database we end up with 51756 Bordeaux and 18147 Rhone observations. This quantity of observations is sufficiently large to overcome the drawbacks of the RSR method that can occur with extremely small datatsets

b. Overview

To expand on previous research, an index construction method - the repeat sales regression method - is used to analyse the data. The method was first proposed by Bailey et al. (1963) to construct a real estate price index and the method has since been applied to other infrequently traded assets such as art (Goetzmann, 1993), (Mei & Moses, 2002), wine (Burton & Jacobsen, 2001), (Sanning et. al, 2007), (Masset & Weisskopf, 2010) and other asset classes. Returns on frequently traded assets (e.g. many stocks on an exchange) are relatively easy to compute and hence their indices are easy to calculate. By contrast, infrequently traded assets present much more of a challenge in the calculation of a price index. Consider the case of real estate; typically a single property will not sell multiple times per year or even per decade. The problem with methods such as taking a volume-weighted average sales price to estimate returns on property is the inter-property quality differences that invariably occur. Location, behavioural attitudes, available floor space, construction quality and many more variables contribute to a property's sales price. One method that may be used to calculate the real return of property as an asset class while minimising the effect of quality differentials is the hedonic regression. This method involves creating variables for every attribute that may affect a property's price e.g. location, available floor space, presence of a garden etc. This approach presents two major challenges; firstly, it is nearly impossible to capture all variables that affect a property's sales price and secondly, many are difficult to quantify. This is highly relevant to the case of wine that faces the same inter-product quality differentials. Even the

same region or producer can produce wine of hugely variable quality from one year to the next such as the case of wines from the Pomerol region which achieved a Parker score of 58 for 1991 and a core of 82 for1992. With so many difficult-to-quantify variables in play, the hedonic regression method is far from ideal for analysing returns on wine as an asset class.

The repeat sales regression method helps to solve this problem. The goal of repeat sales regression is to calculate the index by considering repeat sales of the same product. In the case of property, this involves recording the sale price and date of multiple properties, each selling at least twice. In the case of wine, this involves matching cases of wine of the same producer and vintage sold at different points in time. The benefit of this method is the elimination of differences in quality distorting results, as repeat sales of the same product are only considered. This is much easier for wine data than for house price data as there tend to be more occurrences of repeat sales of specific producers' vintages of wine than houses as wine vintages are produced in multiple-bottle batches. As such, the price appreciation that occurs when an identical wine is sold twice during a period of time is reflective of the general trend in the wine market as well as a unique factor unique to that wine (an error term or noise).

c. Implementation

The model underlying the index was first proposed by Bailey et. al (1963) in the context of house prices and has since been applied to many other infrequently traded assets including wine, art and other collectibles.

For a period of repeat sales 0,…,T, the model can be described for any repeat sale of a wine as follows:

$$R_{n,t_1,t_2} = \frac{P_{n,t_2}}{P_{n,t_1}} = \frac{I_{t_2}}{I_{t_1}} \times U_{n,t_1,t_2}$$

where U_{n,t_1,t_2} is an idiosyncratic error term; $t_1 < t_2$ for t_1 = 0,1,…,T-1, t_2 = 1,2,…,T (Calnea, 2011). R_{n,t_1,t_2} is described as the ratio of the final sales price to the initial sales price in period t_2 for the n-th wine observation, given that P_{n,t_i} refers to the sales price of wine n at time i. This is equal to the ratio of the initially unknown indices (I_{t_1} and I_{t_2}) corresponding to the two periods multiplied by a wine- specific noise term (Calnea, 2011). This model accounts for the overall wine market trend with the two index values and the noise that individual wine observations generate, the idiosyncratic error term.

In practice, the equation described above is difficult to implement as a regression model, therefore the model is transformed into a more suitable linear form, taking the natural logarithm of both sides of the equation as shown (Wang & Zorn, 1997),

$$\ln(R_{n,t_1,t_2}) = -\ln(I_{t_1}) + \ln(I_{t_2}) + \ln(U_{n,t_1,t_2})$$

For ease of notation, lower case letters are used to represent natural logarithms of corresponding capital letters as shown,

$$r_{n,t_1,t_2} = -i_{t_1} + i_{t_2} + u_{n,t_1,t_2}$$

The model proposed by Bailey et. al (1963) assumes that the error term has zero means, constant variance and are uncorrelated with any i_t. The aim of the regression is to estimate I_t, which is achieved only after estimating the range of i_t for the period and adjusting for the logarithmic transformation and the error term.

This is achieved by creating a range of dummy variables, x_t; t=0,…,T, which correspond to the month of the months in the period for which the index is created. The model is rewritten as follows

$$r_{n,t_1,t_2} = -\sum_{t=0}^{T-1} i_t x_t + u_{n,t_1,t_2}$$

where x_t takes the following values when initial and final sales period are t_1 and t_2 respectively,

$$x_t = \begin{cases} -1, \text{if } t = t_1 \\ 1, \text{if } t = t_2 \\ 0, \text{otherwise} \end{cases}$$

In other words, the dummy variable takes a value of -1 in the period of first sale, 1 in the period of repeat sale and 0 otherwise. With these adjustments, the model takes the form of a multiple linear regression with T independent dummy variables.

The model can be estimated by regressing the dummy variables against the log returns using the ordinary least squares (OLS) method. Critically, when creating the model it is imperative that the regression intercept coefficient is set to zero. A non-zero coefficient can significantly distort the regression estimates. The regression coefficients are estimates of $\hat{\imath}$, the natural logarithm of $\hat{I}$, the index values that are sought. It is also material to note that indices typically start at 100, so the base index value $\widehat{I_0}$ takes a value of 100

The relationship between the regression-estimated $\hat{\imath}$ coefficients and the index values of interest, $\hat{I}$, where $\widetilde{I_x}$ is the OLS estimated index value at period x, is as follows,

$$\ln(\widehat{I_t}) = \ln(\widetilde{I_t}) - \ln(\widetilde{I_0}) + \ln(\widehat{I_0}) = \widehat{\imath_t} - \widehat{\imath_0} + \ln(100)$$

In order to return from the regression-estimated coefficient values to the index values of interest, it is necessary to implement the following transformation.

$$\widehat{I_t} = e^{(\widehat{\imath_t} - \widehat{\imath_0} + \ln(100))}$$

In other words, by taking the exponential of the estimate of i for period t minus the estimate of i for period 0 plus the natural logarithm of 100, the estimate of the index value, I, at time t is calculated (Calnea, 2011). This is the last step of the model and represents the estimate of the index value for the period t. All estimates were conducted using the statistical package R.

The main benefit of the repeat sales regression is also the primary argument for its use in this analysis – it facilitates the generation of index estimates for infrequently traded assets. When two identical assets are traded at two different times, the price appreciation or depreciation is attributable to only two attributes of the investment, the general movement attributable to the market for that asset and an error term unique to that asset. When many observations of assets trading repeatedly are gathered and analysed by regression, it is possible to generate index returns for all assets in that class, whether it concerns property, art, wine or any other infrequently traded asset. The model proposes that the idiosyncratic error terms have a mean of zero, constant variance and are uncorrelated to the individual regression-estimated index parameters. The model has proven to be an accurate representation of the overall movements of an index in the index time period, especially when the number of observations greatly exceeds the number of time periods in the index (Goetzmann, 1992).

This method is preferable to other methods, such as a hedonic regression that involves the definition of a large number of variables that may influence the price. This has proven to be difficult

in the case of houses (Geltner & Pollakowski, 2007), even though they have many attributes affecting their price that can be estimated using hedonic regression such as square footage, garden presence and even location. Wine has even fewer tangibly quantifiable attributes that could contribute to a hedonic regression. It is true that wine critics often assign numerical scores to specific wine vintages but these are largely subjective. Additionally, wine scores are often the subject of controversy as they are viewed by some as a self-fulfilling prophecy and can be susceptible to conflicts of interest. With such largely subjective attributes forming the potential basis for wine index estimation using hedonic regression, the repeat sales regression is favourable as it compares like with like, removing the quality differentials between wines and hence stripping out their effect on wine returns.

d. Drawbacks

The repeat sales regression method is not without flaws. Firstly, the sample selection that results from the RSR method is arguably non-random. Sample selection bias in likely to be present in the context of price indices. It has been argued in the case of house prices that the probability of observing a house's price was dependent on the price appreciation it experienced (Galtzlaff & Haurin, 1997). In the context of wine data there is no reason why the same principle would not apply. The value of a property is derived from the proceeds of the sale of the property or the user benefit experienced by continued possession (or consumption) of the property. Similarly, the value of wine is derived from the proceeds of its sale or the user benefit of its consumption (Burton & Jacobsen, 2001). If a wine did not appreciate in value as expected, an investor holding the wine may decide that the utility of consuming the asset exceeds the relative value of selling the asset for return. In such a case, the true return of the asset will not be captured by the RSR method as the data for the repeat sale does not exist. This makes the method susceptible to non-random sample selection and bias wine indices in favour of wine with strong investment performance. Secondly, the RSR method presents a problem known as revision volatility. This refers to the fact that an index may change when re-estimated with additional data (Wang & Zorn, 1997). By executing an RSR on a dataset, the method will compute the index values for each period based on the information available in that dataset. However, if the index is re-estimated using additional repeat sales observations, previously calculated index estimations will change. This is not unexpected – the estimates are based on the original dataset; if the dataset changes, so will the estimates. This presents a problem in that an index computed using this method will never be fully accurate and in fact will evolve over time. Despite this, the current availability of sales data for comparable wines

only allows for estimates of wine index calculation using this method. Real wines indices such as the Liv-ex 100 may be referenced for up to date data but are relevant only to the wines in that index. As such, the RSR method is still a valuable estimator for past investment performance of a wider range of wines.Finally, Case & Shiller (1987) described the concern that heteroscedasticity may be present with the RSR method. Heteroscedasticity occurs when a sequence of random variables have different variances. If this is true of the RSR method, a key assumption of the model proposed by Bailey (1963) is invalidated. However, Case & Shiller conclude that the problem is likely only to occur with small samples and so when the RSR is applied to a larger dataset "ignoring the problem of heteroscedasticity may be justified". Furthermore, the issue of multicollinearity, the case where independent variables have some form of linear relationship may arise with the use of the RSR method as proposed by Cho and described by Calnea (2011). The biggest issue this presents to wine hammer prices is that small changes in data may have large effects on parameter estimates. It is concluded that this is likely to be a problem only with small datasets, as with the problem of heteroscedasticity. With sufficiently large datasets, the RSR method presents no material risk to parameter estimates as a result of multicollinearity.

Whilst there are some disadvantages to the RSR method, the aim of this paper is to draw conclusions on the historical performance of wine investment through historical index construction and comparison. The infrequent nature of wine trading makes this task particularly difficult. The use of a hedonic regression is suboptimal due to the emotional nature of the asset and the subjective methods used to classify wine quality. Any hedonic regression researched and constructed would have the added problem of quantifying such variables. The RSR method removes this problem and strips out the quality differentials between different wines by comparing the prices at which wines sell repeatedly. Although the model assumptions do present some problems, the model has been applied several times in the past with useful results. Many of the technical problems presented by the RSR method can be overcome with a sufficiently large dataset. The dataset in this research for each index is sufficiently large to mitigate these problems. Coupled with past research and current data such as the Liv-Ex 100, the RSR method is appropriate for the purpose of explaining the behaviour of these wine indices and forming views on how the market may behave in the future.

4. RESULTS

a. Inter-regional index analysis

Figure 1 shows the evolution of the Red Bordeaux & Rhone regional indices and combined index for both regions, compared to the Dow Jones Industrial Average (DJIA) for the period January 1996 – January 2007.

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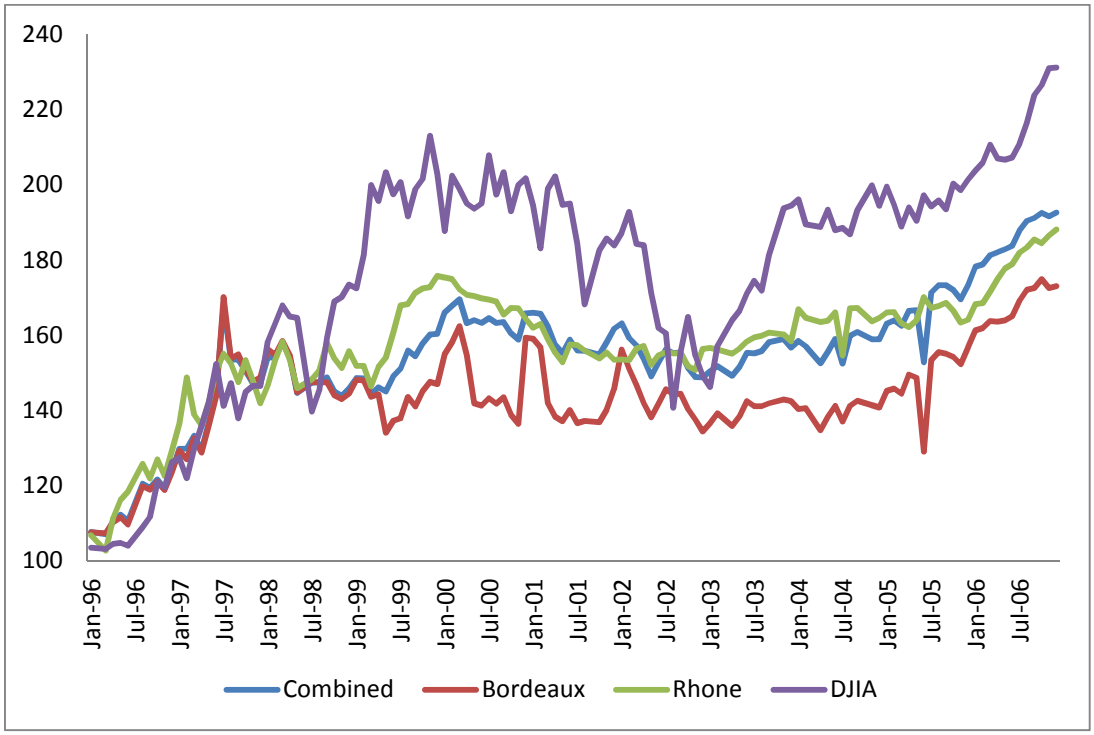
Figure 1 Evolution of Red Bordeaux & Rhone regional indices, combined regional index and the DJIA for the period January 1996 – January 2007



Both regional wine indices experience almost equally strong initial appreciation until approximately January 1999 when the Rhone region overtakes the Bordeaux region. In the two years to 1998, the wine indices yielded highly attractive returns of almost 20%, approximately in line with the DJIA. Despite initially closely matching the DJIA, the stock index appreciation accelerates faster than all three wine indices around this time, likely fuelled by the tech bubble of the late 1990s – early 2000s. Throughout the period 2000-2004, all three wine indices essentially held their value with some moderate appreciation and depreciation from quarter to quarter. The Bordeaux region experienced more variation in returns than the Rhone region, which is somewhat surprising given that Bordeaux sales observations exceeded Rhone sales observations in the dataset by almost 3 to 1. As it is more frequently traded, it was expected that the Bordeaux index would be smoother and the

apparent volatility seen in the index from 2000-2002 in particular highlights the changeable nature of Bordeaux wine returns. This rapid price volatility could indicate some evidence in support of the emotional nature of the asset. From late 2001 throughout 2002 the DJIA lost much of its lead on the wine indices, dipping below all three around July 2002, likely due to the bursting of the tech bubble. However, the DJIA bounced back quickly and experienced phenomenal appreciation during 2003, which slowed to a more modest level from 2004-2007. All three wine indices experienced relatively moderate yet persistent appreciation from January 2004 to 2007, with strong growth in the Bordeaux region allowing it to catch up with the Rhone region and force the combined index on top for the period end due to the higher volume of Bordeaux sales in the index.

It is clear for the period that the wine indices did not experience the same overall appreciation as the DJIA however the indices reveal a number of times when it would have been more advantageous to be a wine investor than a DJIA investor. To further analyse the benefits of wine returns, Table 1 describes yearly return data for the indices.

Table 1 :Yearly returns to Bordeaux, Rhone and combined wine indices compared to the DJIA

Year	Combined	Bordeaux	Rhone	DJIA
1996	19.20%	18.90%	22.60%	26.01%
1997	18.70%	19.50%	14.30%	22.64%
1998	-2.30%	-3.90%	6.60%	16.10%
1999	9.80%	2.20%	10.90%	25.22%
2000	-1.00%	-7.20%	-4.90%	-6.18%
2001	-4.60%	-12.00%	-5.50%	-7.10%
2002	-8.70%	-5.90%	-1.80%	-16.76%
2003	6.90%	6.40%	2.50%	-25.32%
2004	1.40%	-0.80%	3.30%	3.15%
2005	6.70%	8.20%	-0.70%	-0.61%
2006	10.50%	10.00%	13.60%	16.29%
Average	5.20%	3.20%	5.50%	4.90%
Volatility	9.10%	10.40%	8.90%	17.60%
Years exceeding DJIA	5	3	5	

These results clearly show the benefit of wine as an investment over investment in stocks as represented in this research by the DJIA.Returns to all three wine indices have significantly lower volatility (standard deviation) than the DJIA, making the investments less risky than investment in the stock market. The returns to the wine indices in many years are strong, with average yearly returns to the combined index of 5.2%, far in excess of the return earned by one year US T-bills in recent times (US DOTT, 2011). This finding is in line with Jaeger (1981) and in contradiction of Krasker (1979), indicating that the behaviour of wine is similar over time and there is a risk premium to holding wine as an investment. The most substantial yearly loss incurred by the combined wine index is 8.7%, compared to 25.3% by the DJIA. The strongest yearly gain to the combined index is 19.2% compared to 26% on the DJIA. The wine indices do not follow the same market patterns as the DJIA year-on-year. For example, in 2003 the DJIA suffered its worst loss for the period however all three wine indices reported price appreciation for the year.

Clearly Rhone gives a stronger investment performance compared to Bordeaux in this period however towards the end of 2006 Bordeaux showed promising signs of catching up on its rival. It is also noteable that both the combined and the Rhone wine index outperformed the DJIA for 5 of the 11 years in this analysis. Further analysis of Table 1 shows that many of these cases occur on years when the DJIA suffers losses, in which case the wine indices suffer either more modest losses or gains. This behaviour is similar to that of fixed income products that generally carry lower risks and

lower returns than stocks, however the volatility of these wine indices shows that they still carry a significant amount of risk. Furthermore, given that the Rhone region significantly outperformed the Bordeaux region, the issue of wine selection on investment returns arises and will be addressed in the following section.

b. Intra-regional index analysis

To consider the effect of wine selection on index performance, indices were constructed for five wine sub-regions in the Bordeaux region and for five individual wines from the Rhone region. These were compared to the corresponding regional index. Figure 2 shows the evolution of the Bordeaux index and the sub-indices for the popular Bordeaux sub-regions St. Estephe, Pauillac, St. Julien, Pomerol and St. Emilion. Each sub-region consisted of a number of wines from that region. Sub-regions are significant in Bordeaux as each occupies a given area of land with unique attributes for wine production such as soil composition. Each sub-region's wine is viewed as having attributes common to the vineyards in that sub-region, yet distinct from other sub-regions. It is even possible for one sub-region to receive wine scores that are completely out of sync with other sub-regions, as seen with a poor wine score of 52 issued to Pomerol wines in 1991 by Robert Parker.

Figure 2 Evolution of the Bordeaux wine index and five sub-regional indices for the period January 1996 January 2007

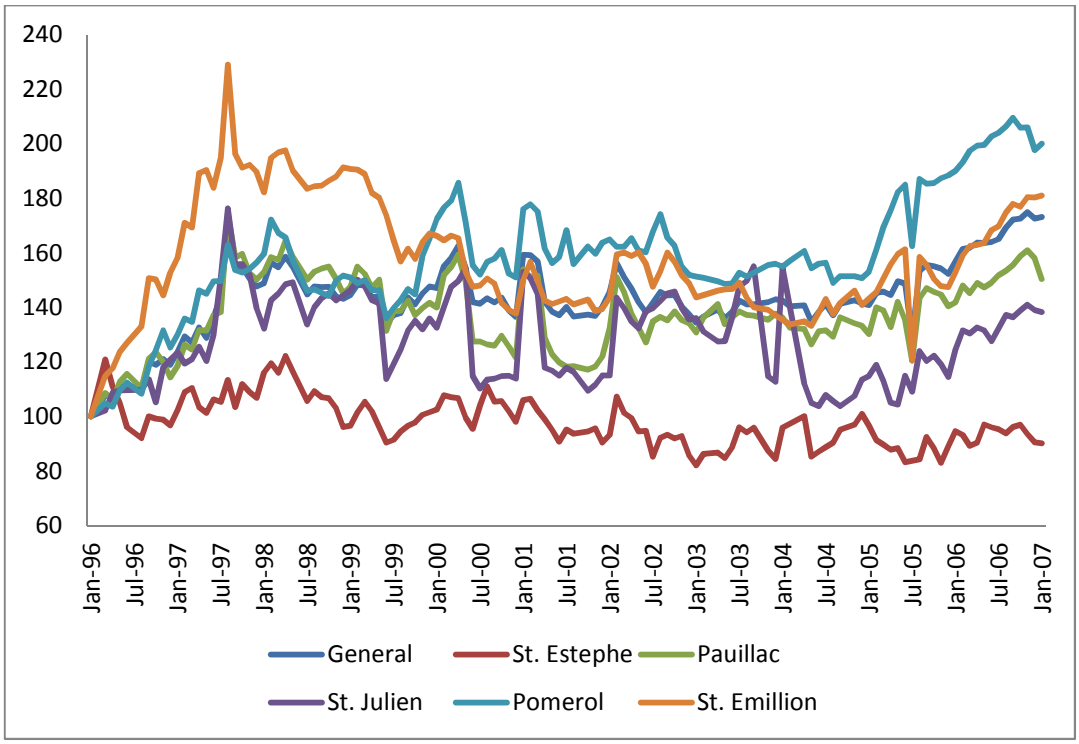


Figure 2 illustrates the vast difference in returns produced by wines in the sub-regions of Bordeaux and the opportunities these present. For the period, Pomerol appreciated the most in cumulative terms, however St. Emilion was not far behind it in January 2007, with both sub-regions exceeding the cumulative regional index. The variance in returns from each sub-region is striking, for example St. Julien is particularly volatile from 1999 to 2004. St. Emilion had a sensational performance from 1996 to mid 1997, however the sub-region quickly began losing value from this point on. Had the indices started from 1998, St. Emilion's index would be in a far worse state. St. Estephe is the most poorly performing sub-region for the period, barely managing to hold its value over the 11 years, however the returns were volatile on this index and opportunities for investors were present if the timing was right. To further understand the nature of Bordeaux's wine returns, Table 2 describes the yearly returns to each of the five sub-regions.

Table 2 Yearly returns to the sub-regional Bordeaux wine indices

Year	General	St. Estephe	Pauillac	St. Julien	Pomerol	St. Emilion
1996	18.90%	-3.30%	14.30%	20.80%	25.30%	52.80%
1997	19.50%	4.30%	26.70%	13.00%	20.30%	19.80%
1998	-3.90%	-17.10%	-5.20%	9.20%	-5.00%	5.00%
1999	2.20%	5.10%	-3.90%	-7.10%	9.30%	-12.40%
2000	-7.20%	-4.40%	-13.10%	-14.10%	-12.40%	-17.20%
2001	-12.00%	-14.70%	-20.80%	-24.80%	-7.00%	-7.10%
2002	-5.90%	-8.70%	1.30%	15.10%	-8.50%	3.50%
2003	6.40%	2.80%	5.30%	-17.10%	3.10%	-4.50%
2004	-0.80%	5.30%	-2.20%	-26.50%	-2.80%	4.00%
2005	8.20%	-7.80%	7.80%	-0.30%	23.10%	3.00%
2006	10.00%	-4.30%	11.40%	11.70%	4.00%	17.90%
Average	3.20%	-3.90%	2.00%	-1.80%	4.50%	5.90%
Volatility	10.40%	7.80%	13.20%	17.00%	13.40%	19.20%

Table 2 the risky nature of individual Bordeaux wine investment. The general index has a cumulative average return of 3.2% with a volatility of 10.4%. As noted in section 5.1, this was less preferable than the corresponding Rhone index. St. Emilion had volatility (19.2%) in excess of even the DJIA (17.4%) over the period. Clearly this shows that investment in individual wines for financial purposes is potentially more risky than investment in stocks. Despite this, some sub-regions yielded incredible returns that would have been incredibly profitable if transaction timing was optimised. This analysis begins to suggest that direct wine investment by inexperienced or low volume investors could pose risks in excess of those posed by the stock market. However, given the lower risk posed by a cumulative wine index and the potential for strong returns, this suggests that wine funds could be the most desirable method for investment in this asset class. The benefit of investing in a wine fund would be twofold; firstly, the range of wines in the fund would provide natural diversification to reduce variance and smooth returns and secondly, a wine fund would have more resources with which to attract expert knowledge of the wine industry and hence improve returns by optimising transaction timing.

Figure 3 shows the evolution of 5 individual wines from the Rhone valley region. The wines selected were the most frequently traded Rhone wines in the dataset. Wines from the Rhone region are not traded as frequently as Bordeaux wines and as such some wines do not span the entire period; however, the indices were constructed insofar as the data allowed for comparison purposes.

Figure 3 Evolution of the Rhone wine index and five individual wine indices for the period January 1996 – January 2007

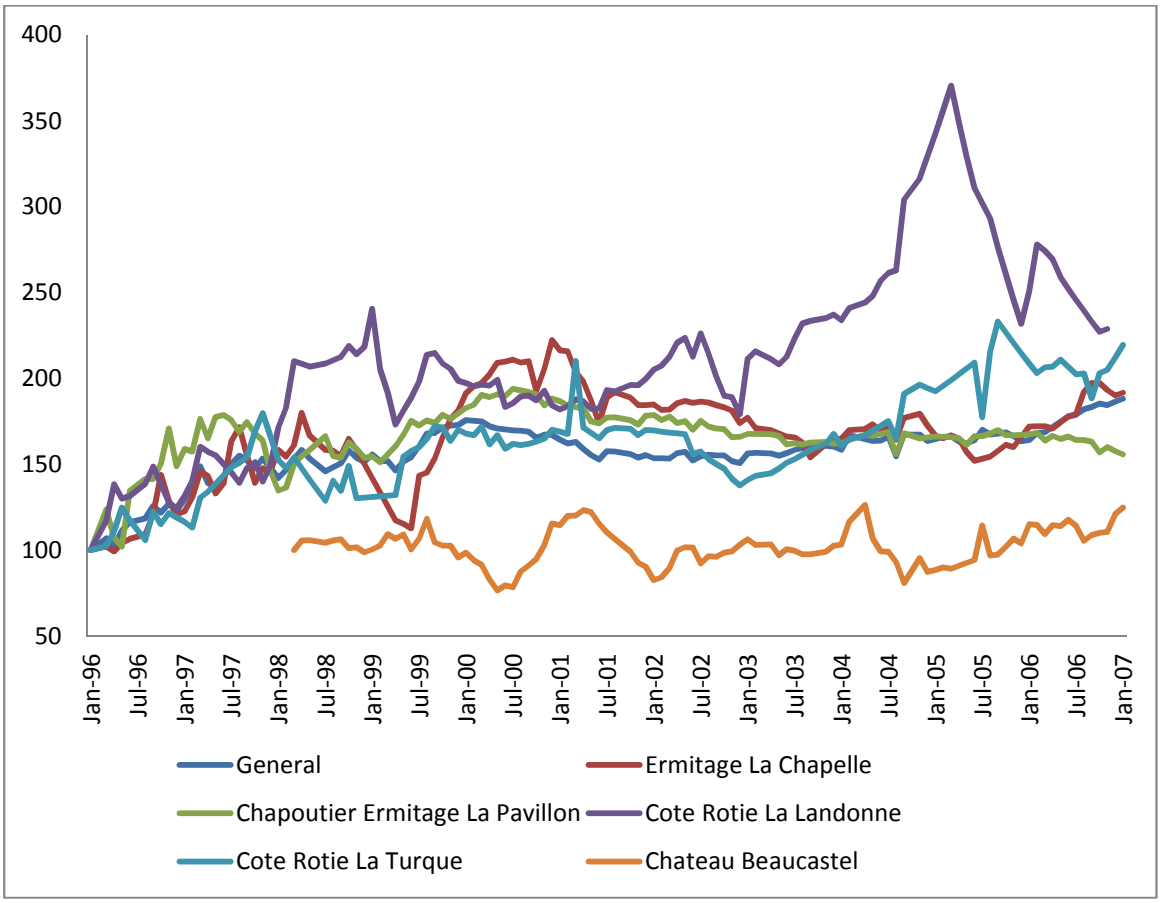


Figure 3 exhibits some similarities to figure 2, as it is clear that there is significant variance between individual wine returns. Three of the wines follow the general Rhone index relatively closely, however Cote Rotie La Landonne yields extremely volatile jumps throughout the period. Additionally, Chateau Beaucastel does not experience the same appreciation as the rest of the wines in this example. Whilst the index does start two years later, it hovers above and below its original value for several years before experiencing an upturn towards the end of the period. In order to further understand the behaviour of yearly returns to the wine indices, consider Table 3 detailing the yearly returns of each index.

Table 3 Yearly returns to individual wines in the Rhone region

Year	General	Ermitage La Chapelle	Chapoutier Ermitage La Pavillon	Cote Rotie La Landonne	Cote Rotie La Turque	Chateau Beaucastel
1996	22.60%	20.70%	48.80%	24.30%	19.10%	NA
1997	14.30%	18.60%	-8.10%	13.50%	54.40%	NA
1998	6.60%	0.10%	14.10%	27.40%	-14.70%	-1.30%
1999	10.90%	NA	16.10%	-17.40%	NA	-4.70%
2000	-4.90%	16.20%	3.00%	-6.60%	1.30%	17.30%
2001	-5.50%	-14.80%	-4.50%	9.90%	0.60%	-21.10%
2002	-1.80%	-6.20%	-7.70%	-14.50%	-23.20%	20.00%
2003	2.50%	-7.10%	-3.40%	12.30%	19.10%	-3.50%
2004	3.30%	4.70%	2.20%	40.80%	20.90%	-15.40%
2005	-0.70%	-0.50%	0.50%	-32.30%	11.50%	17.60%
2006	13.60%	10.50%	-5.90%	NA	1.60%	5.10%
Average	5.50%	4.20%	5.00%	5.70%	9.10%	1.60%
Volatility	8.90%	12.00%	16.60%	22.90%	21.60%	14.70%

Similarly to what was observed in the Bordeaux region, Table 3 illustrates higher variance and hence risk associated with individual wine investment. Both Cote Rotie La Landonne and Cote Rotie La Turque exhibit standard deviations in excess of the DJIA, however these were clearly the top performing wines in the index. This shows that wines with higher return potential can carry more risk in line with the conclusion of Masset and Weisskopf (2010). These results add further weight to the argument that direct investment in individual wines is not ideal for investors as the risk accepted can potentially be higher than the stock market and the returns earned may not reflect this risk premium borne by investors. Comparing the individual returns to the overall wine index returns the diversification benefit of a multiple-wine index is confirmed. These results strongly suggest that investment in wine is most effective at the indirect wine fund level and the benefits of diversification and resources to make optimal trading decisions further support the notion of wine fund investment.

c. Analysis of wine fund and index performance

To analyse the case for wine as an investment, returns to a number of wine funds, in addition to The Wine Investment Fund mentioned in section 1, were analysed. The funds analysed were The Vintage Wine Fund, managed by Andrew Davison (TVWF, 2011), The Wine Investment

Fund, managed by Andrew della Cassa and Rodney Birrell (TWIF, 2010), Singapore-based Premium Wine Fund No. 1 (PWF, 2011) and Wine Asset Management LLP (WAM) advised by Steven Spurrier (WAM, 2011). The evidence above suggests that diversification and optimal decision-making can increase returns and decrease volatility. If the theory is correct, it is expected that these funds will be able to achieve superior returns and lower volatility than the indices above by reaping the benefits of diversification and expert knowledge. Table 4 illustrates the returns of each of the wine funds analysed.

Table 4 Annual returns to a selection of major wine funds for the years 2003-2010

Year	The Vintage Wine Fund	The Wine Investment Fund*	Premium Wine Fund No. 1	WAM Fine Wine Fund	WAM Fine Wine Investment Fund
2003	6.22%	15.84%			
2004	2.12%	13.01%			
2005	11.18%	15.17%			
2006	23.97%	12.86%		7.90%	
2007	23.97%	6.96%	9.57%	29.80%	-1.40%
2008	-33.37%	16.74%	4.01%	-17.00%	-15.10%
2009	0.02%	20.11%	24.26%	7.60%	8.10%
2010	32.31%	9.67%	7.39%	35.60%	31.10%
Average	8.30%	13.80%	11.31%	12.78%	5.68%
Volatility	20.44%	4.14%	8.93%	20.90%	19.44%

* Average yearly tranche returns

The results are not entirely consistent with the proposed theory. The funds analysed have a range of average yearly returns, all of which exceed that of the general Rhone and Bordeaux Wine Index. This supports the theory that wine investment funds are able to make superior decisions by careful wine selection. However, the volatility experienced by three of the five funds is as high as the stock market, which is surprising as a wine fund should be able to reduce variance through diversification of the wine included in the fund. Further analysis of the unexpectedly high variance points to the year 2008 as a large factor in producing such high volatility. Each of the three funds in question suffered heavy losses in 2008 as a result of the GFC. Both of the WAM funds have been in operation for five years or less and so the 2008 losses magnify the volatility significantly. The Vintage

Wine Fund reported positive returns (often in excess of 20%) every year since 2003 with the exception of a 33% loss in 2008. This single loss was a major contributor to the variance in this case. Furthermore, the fact that three of the five funds experienced such heavy losses in 2008 confirms that wine is not immune to the market cycles despite the assertions of Sanning et. al (2007), in this case, the wines in these funds did not have "effectively zero betas".

This analysis reveals mixed conclusions as while some funds have high risk and mixed returns, The Wine Investment Fund emerges as a clear example of a successful wine fund. Since 2003 the fund has reported average yearly tranche returns of 13.8% with volatility at just 4.14%[1]. This return is highly desirable for such a low level of risk. Despite this; however, the poor returns of the other wine funds analysed cannot be ignored. The majority of the wine funds analysed carry a higher yearly return variance than the DJIA and were not immune to the GFC of 2008. The GFC of 2008 was a period of unprecedented market turmoil during which the behaviour of many financial assets was entirely unexpected and unpredictable. For the purpose of comparison, the average return and standard deviation for each wine fund was calculated, omitting the year 2008, as shown in table 5

Table 5 Average annual returns to a selection of major wine funds for the years 2003-2010 excluding 2008

	The Vintage Wine Fund	**The Wine Investment Fund***	**Premium Wine Fund No. 1**	**WAM Fine Wine Fund**	**WAM Fine Wine Investment Fund**
Average	14.26%	13.37%	13.74%	20.23%	12.60%
Volatility	12.51%	4.28%	9.18%	14.60%	16.71%
	* Average yearly returns				

Table 5 shows the vast improvements in the average return and volatility for each of the wine funds when 2008 is excluded. The data shows that for all other years fund volatility was below that of the DJIA for all funds and average returns drastically improved. Whilst removing 2008 gives an unrealistic view of the entire wine market, it does imply that under normal market conditions wine fund investment is very attractive and potentially highly lucrative. This reinforces the

[1] Note that the years in question refer to the tranche inception, each of which lasts 5 years and are reported on a cumulative annualised basis.

conclusions drawn from the Rhone and Bordeaux indices that wine can be an attractive investment prospect, but shows that wine is not an entirely reliable asset for holding value in a market downturn.

The divergence of the performance of the above funds is somewhat surprising, particularly in the year 2008 as so many investors sought to convert their investments to cash and indeed the Liv-Ex Fine Wine 100 index suffered losses (discussed in following section). Further investigation into individual fund losses suggests that factors beyond the wine market contributed to the losses. TVWF in their December 2008 bulletin cite "essentially foreign exchange related reasons for our very disappointing performance in December" which accounted for more than 50% of the 2008 loss (TVWF, 2008). Furthermore, WAM claim that their 2008 performance of -17% was in line with market expectation and make reference to one other fund in the following context: "We think we may have unearthed the world's most over-valued fund … It appears that valuation premiums of up to 150% have been applied to its entire first growth portfolio … One has to pity the poor investors who have bought in at such a premium. Merchants will usually apply a 10% premium at most when selling ex-Chateau stock, but only really on older vintages. … Not surprisingly, with such a fantastical methodology, they have recorded a rather strong performance in 2008, including the last four months." (WAM, 2008The fund is not named, WAM claim it is based in the Middle East and there is no evidence to suggest that it pertains to any of the funds analysed as part of this research. However, it does raise the question of wine fund valuation practices and highlights TWIF (for whom Liv-Ex value their portfolios) as excellent asset managers as their cumulative annualised average tranche returns are strong, with only the 2007 tranche showing evidence of the adverse effects of the GFC in 2008.

d. Analysis of the Liv-Ex Fine Wine 100 Index

The Liv-Ex was named the wine industry's leading benchmark by Reuters in November 2008 (Liv-Ex, 2011). Figure 5.4 shows the evolution of this index over the past 11 years.

Figure 4 Evolution of the Liv-Ex Fine Wine 100 from July 2001 – June 2011

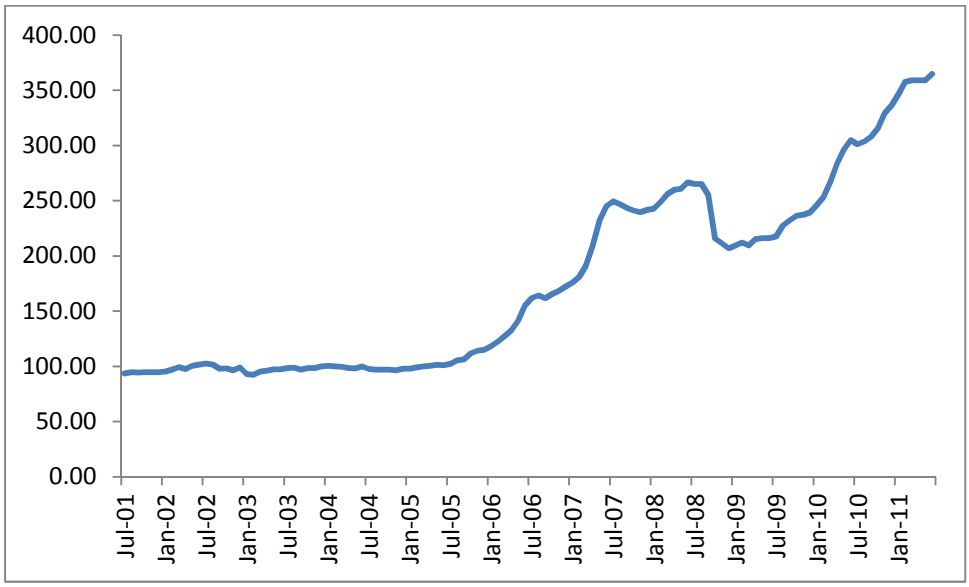


Figure 4 confirms the results discussed in section 5.1 as the initial period of the Liv-Ex Fine Wine 100 index (FW100), from July 2001 – approx. July 2005 is relatively flat and the index holds its value with some minor deviations from quarter to quarter. This is consistent with the results estimates in the Rhone and Bordeaux wine indices. The index starts to appreciate significantly from approx. July 2005 throughout 2006, once again consistent with the estimates found in section 5.1, however the dataset in this research does not continue past January 2007. Assuming the indices wecalculate continued to appreciate in line with the FW100, Bordeaux and Rhone wines would be expected to appreciate significantly in the following years. Masset and Weisskopf (2010) estimated this to be correct. The FW100 reveals the strong returns to wine as an investment throughout the last 5 years and illustrates that the wine market as a whole was affected by the GFC of 2008. The wine funds that sustained losses in 2008 should not be viewed as exceptional. Indeed, TWIF in particular should be recognised for delivering strong returns for 2008. Returns for the period averaged 14.15% with a standard deviation of 20.13%. This offers a high level of risk but a corresponding high average return over the entire period of the index. It also supports the finding that wine at the high end of the market (as this is the fine wine 100 index) carries high return potential with a corresponding high level of risk. In this context wine cannot be portrayed as a low

risk investment but with careful fund selection it is possible to find a range of funds with varying risk and return profiles. This leads to the conclusion that for many investors wine is an attractive investment prospect.

e. Comparative Analysis

To further assess the performance of the above assets, Sharpe ratios were calculated for analysis. The Sharpe ratio is defined as follows:

$$\frac{\bar{r}_p - r_f}{\sigma_p}$$

where $\bar{r}_p$is the expected portfolio return, r_f is a measure of the risk free rate of return and σ_p is the standard deviation of the portfolio. The Sharpe ratio gives a measure of how a portfolio performed relative to its level of risk - the greater a portfolio's Sharpe ratio, the better its risk-adjusted return. A negative Sharpe ratio indicates the portfolio performed worse than a risk-less asset. A portfolio with a high return but a low Sharpe ratio indicates that the return is as a result of high risk. In general, a Sharpe ratio of 1 is good, 2 is very good and 3 or higher is excellent. The risk-free rate used to calculate the Sharpe ratios that follow are the average 5-year US T-Bill rate over the period in question.

Table 6 Sharpe ratios for the Bordeaux, Rhone, combined Bordeaux-Rhone indices and the DJIA for the period January 1996 – January 2007

	Combined	Bordeaux	Rhone	DJIA
Portfolio Return	5.20%	3.20%	5.50%	4.90%
Portfolio Std. Dev.	9.10%	10.40%	8.90%	17.60%
Avg. 5-year T-Bill rate	4.80%	4.80%	4.80%	4.80%
Sharpe Ratio	**0.039**	**-0.153**	**0.082**	**0.003**

Table 6 illustrates the Sharpe ratios of the Rhone, Bordeaux, combined Rhone-Bordeaux indices and the DJIA. None of these ratios are considered strong as all fall far short of 1. This is as a result of the high volatility associated with the returns relative to the excess average return over the risk free rate for the period. Both the Rhone and the combined indices give a better risk-adjusted return than the DJIA based on the above ratios. The Bordeaux region has a negative Sharpe ratio, indicating that a "risk free" 5-year T-Bill would have given an investor a better return for the period than the Bordeaux index. These ratios confirm the earlier findings that after adjusting for return volatility, wine is only questionably an attractive investment and only marginally more attractive to a risk-averse investor than the DJIA.

The Sharpe ratios were calculated for the sub-regional Bordeaux indices and the individual wine indices of Rhone, illustrated in table 7.

Table 7 Sharpe ratios for sub-regional Bordeaux indices and individual Rhone indices for the period January 1996 – January 2007

	Bordeaux					
	General	**St. Estephe**	**Pauillac**	**St. Julien**	**Pomerol**	**St. Emillion**
Sharpe Ratio	-0.153	-1.114	-0.215	-0.392	-0.023	0.056
	Rhone					
	General	**Ermitage La Chapelle**	**Chapoutier Ermitage La Pavillon**	**Cote Rotie La Landonne**	**Cote Rotie La Turque**	**Chateau Beaucastel**
Sharpe Ratio	0.082	-0.048	0.013	0.04	0.197	-0.221

Unsurprisingly, almost all of Bordeaux's sub-regions return negative Sharpe ratios indicating that all sub-regions with the exception of St. Emillion performed worse than a 5-year US T-Bill on a risk adjusted basis. Rhone's individual wines displayed a slightly better performance than Bordeaux,

with only 2 out of 5 wines having negative Sharpe ratios. Despite this, as none of the ratios approach 1, the ratios are still poor performance indicators for these assets in general. This is due to high volatility levels which make these assets particularly risky and average returns which are close to the risk free rate.

Table 8 Sharpe ratios for selected wine funds 2003-2010

Year	The Vintage Wine Fund	The Wine Investment Fund*	Premium Wine Fund No. 1	WAM Fine Wine Fund	WAM Fine Wine Investment Fund
Average	8.30%	13.80%	11.30%	12.80%	5.70%
Std. Dev	20.40%	4.10%	8.90%	20.90%	19.40%
Avg. risk free rate	3.30%	3.30%	2.80%	3.20%	2.80%
Sharpe Ratio	**0.244**	**2.532**	**0.948**	**0.457**	**0.146**

Table 8 illustrates the Sharpe ratios for the wine funds analysed earlier. Note not all wine funds were in operation for the entire period and hence different average risk free rates apply. All of the funds have more attractive Sharpe ratios than the regional indices analysed previously, and as such represent better risk adjusted investments than those indices, even including the poorly performing GFC year of 2008 which caused significant returns volatility. TWIF stands out as a very good risk-adjusted fund performer, with a Sharpe Ratio of 2.53 and Premium Wine Fund No.1 returns a strong Sharpe ratio of 0.95. This supports the theory that wine funds produce better risk-adjusted returns through diversification and expert resources, however the divergence in performance is still very clear with 3 of the 5 funds returning poor Sharpe ratios, indicating high levels of risk for their return.

f. Volume Analysis

Figure 5 Sales volumes of standard bottles sold in Bordeaux & Rhone for the period January 1996 – January 2007

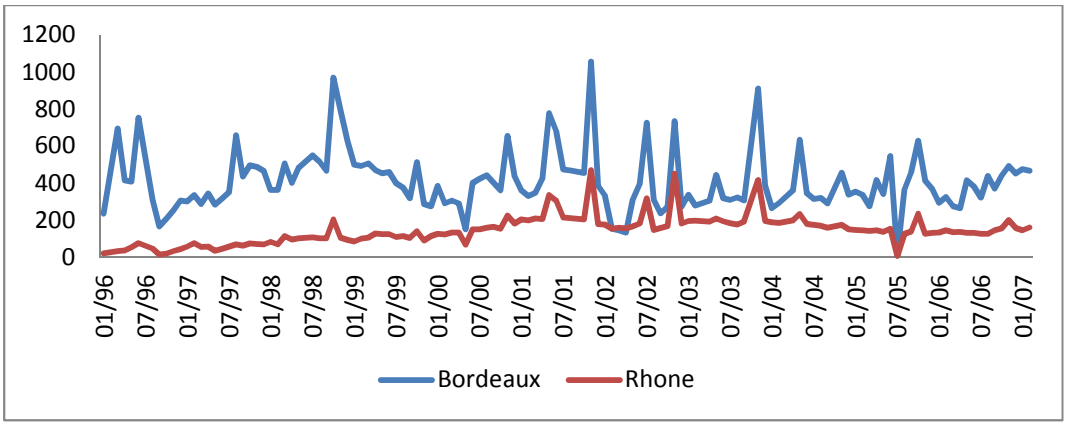


Figure 5 describes the evolution of monthly sales volumes of standard bottles of Bordeaux and Rhone wine for the period analysed. The chart illustrates the far greater frequency of trading Bordeaux wines over Rhone wines and it is this that causes the weaker, more volatile returns of the Bordeaux index to be surprising. The trend of the Bordeaux trading volume is relatively flat for the period but suffers significant volatility from month to month with strong evidence of seasonal effect at year-ends. There appears to be a slight upward trend from 1997 to 1999, which decreases by 2001. Although monthly trading volumes are highly volatile, overall yearly volumes appear flat. The Rhone region experiences sales volume growth from 1996 to approx. 2001 which appears to flatten until 2005 when it begins to decrease slightly. Due to the relative yearly consistency of both sales volume curves and the significant monthly volatility that appears to repeat seasonally, it is not expected that unexpected increase or decrease in sales volumes of the market as a whole influenced yearly index returns.

g. Comparison with other collectibles

The wider market for collectibles does not appear to show the same appetite for investment funds as seen in the wine market. Arguably the next most popular asset, art, is traded at fund level by the London-based Fine Art Fund Group details of which however are available only to investors. Dutch Bank ABN-AMRO created an art fund in 2004 but moved out of the entire market by 2005 as "the available art funds were not sufficient to put together a fund of funds" (Adam & Mason, 2005). As such, academic research must be relied upon for return estimates. One study asserts that the annual return to fine art on an inflation-adjusted basis was a mere 1.6% from 1950 and as low as 0.55% prior to that (Burton & Jacobsen, 2001). A further study by Goetzmann (1993) estimates the annual returns to fine art over the period 1715-1986 using the RSR method. It concludes that

painting prices growth from 1850-1986 averaged 6.2% for the period, in excess of even stocks. However, this impressive return is accompanied by high volatility with strong correlation to other investments, particularly stocks. Ultimately art is deemed unlikely to be the superior investment. Other collectibles suffer from the same lack of investment at fund level and so academic research must be relied upon in their analysis also. The returns on stamps for the period 1900-2008 were estimated using the RSR method and it was concluded that stamped yielded a nominal annual return of 7% however like wine and art the volatility of returns approached that of equities and some correlation with the equity market was evident (Dimson & Spaenjers, 2011). Finally, an examination of the return performance of rare U.S. coins concludes that returns to this asset close are both low and volatile however rarer coins appear to be better investments (Delorme et. al, 1994). From the indices constructed in this research and the evidence common to other studies it is clear that wine and other collectibles exhibit similar return behaviour of low annualised average returns with high volatility. The analysis of wine funds shows that at fund level, wine investment can reap the benefits of diversification and expert knowledge in many cases. However, wine is a unique collectible given its frequency of trading. It is the frequent auctions and (comparative) abundance of data that creates opportunities for wine funds that are not available to other collectibles. This is confirmed by the inability of ABN-AMRO to successfully create fund products and ultimately exit the market after less than a year.

5. CONCLUSIONS

In summary, we conclude that wine is an attractive investment but comes with a number of caveats. Firstly, the indices constructed show that at a cumulative index level wine can yield returns in excess of “risk-free” assets such as T-bills with significantly lower risk than the stock market. However, at individual or sub-regional levels the return varies significantly and volatility is high, making direct investment in wines unattractive for low volume or inexperienced investors. There is evidence that indirect investment via wine funds and traded indices is a more attractive prospect due to the benefits of diversification and industry expertise that come with these products. Evidence shows, however, that the majority of these products were not immune to the GFC and some carry volatility as high as many stock indices. These general conclusions about wine investment performance mirror those of many other collectibles. As such, this research concludes that wine is certainly an attractive investment instrument but for the majority of investors, the investment methods available to them carry a significant level of risk.

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Appendix A simple example of repeat sales

The following example is adapted from Geltner and Pollakowski's (2007) house price example and applied to real hammer price data from our dataset. Assume the wine index consists of two wines – Chapoutier Ermitage 1994 (CE94) and Dominus Napa Valley 1995 (DN95). To calculate the returns for the period April 1999 – June 1999, sales data is available as described in Table 9

Table 9: Infrequent sales price examples

	Apr-99	May-99	Jun-99
Chapoutier Ermitage 1994	133		135
Dominus Napa 1995	116.25	118.5	

CE94 earned a return of approx. 1.50% between the period April 1999 and June 1999, however in the example May's sales data has been omitted. It is not known if the return is attributable in any way to April, hence affecting May's sales price. The full 1.50% appreciation could have occurred in April, it could have occurred partially in both April and May or it could have appreciated by more than 1.50% in April and depreciated in May. To solve this problem we turn to DN95's sales price.

DN95 earned a return of approx. 1.94% in the month of April. The aim of the repeat sales regression is to use this information to determine the return for the month of April and the month of May. Two dummy variables – Xmay99 and Xjun99 are used. These dummy variables represent whether that month is part of the return's holding period. Their value is one if the month in question is after the month of first sale and before or including the month of the repeat sale i.e. if the month's in question are part of the holding period, otherwise their value is zero. The dummy variables are illustrated for our example in Table 10 below.

Table 10: Example using dummy variables

	Y	Xmay99	Xjun99
CE94 Observation	1.50%	1	1
DN95 Observation	1.94%	1	0

The regression equation takes the form of:

$$Y = a_{may99}(Xmay99) + a_{jun99}(Xjun99)$$

where a_x are the parameters to be estimated by the regression. In this simple example, it is possible to solve this system and hence estimate the parameters with simple algebra. The equations for the example are as follows:

$$1.50\% = a_{may99}(1) + a_{jun99}(1)$$
$$1.94\% = a_{may99}(1) + a_{jun99}(0)$$

This is a system of linear equations which is solved as follows:

$$1.50\% = a_{may99} + a_{jun99}$$
$$a_{may99} = 1.94\%$$

and so:

$$a_{jun99} = -1.94\% + 1.50\%$$
$$a_{jun99} = -0.44\%$$

In the above example, it is known that the return for the month of April (corresponding to a_{may99}) is 1.94% as the hammer price for the first of April 1999 And May 1999. It is assumed that the wine in the index generates the same return and so the return for the month of May is computed. The return for April and May together is known (1.50%) and the return for April alone is known (1.94%) and so it follows that the return for May alone is -0.44%.This simple example can be generalised and applied to much larger datasets with more observations to calculate increasingly accurate estimates for monthly returns..