Published in " The quarterly review of economics and finance", 2021, vol. 82, pp. 1-25, which should be cited to refer to this work.
DOI: 10.1016/j.qref.2021.06.023

Analyzing the risks of an illiquid and global asset: The case of fine wine

Philippe Masset[♣], Jean-Philippe Weisskopf[♣], Jean-Marie Cardebat[♦]
Benoît Faye[♠], Eric Le Fur[♠]

This version: July 2021

Abstract

We use a unique and very deep database to examine the performance of wine investments over the period 2003–2014. Our results reveal that the returns stemming from those investments are important but can largely be explained by their exposure to common risk factors. It appears essential to properly account for the lack of liquidity on the wine market and its exposure to global currency risk. Controlling for these wine market specificities and contradicting prior evidence, fine wines do not seem to offer abnormal returns.

JEL Classification: Q14, G11, C50

Keywords: wine, alternative assets, liquidity, exchange rate

[♣] Ecole hôtelière de Lausanne, HES-SO // Haute école spécialisée de Suisse occidentale, Route de Cojonnex 18, 1000 Lausanne, Switzerland. Emails: philippe.masset@ehl.ch (contact author); jean-philippe.weisskopf@ehl.ch

[♦] Université de Bordeaux, Avenue Léon Duguit, 33608 Pessac, France. Email: jean-marie.cardebat@u-bordeaux.fr

[♠] INSEEC, Hangar 18 – Quai de Bacalan, 33070 Bordeaux, France. Emails: bfaye@inseec.com; elefur@inseec.com

1 Introduction

Since the early 2000's, considering fine wine as an investment category has become progressively more common. Different financial tools on fine wines (e.g., wine indices and funds) have appeared and have attracted investors and alike. This increase in popularity is due to fine wines' strong performance coupled with low risk and correlations with respect to other assets. Research papers provide support for this belief. In particular, Sanning, Shaffer, and Sharratt (2008) show that investments in fine wines tend to generate positive abnormal returns, while Masset and Henderson (2010) further demonstrate that adding such assets to a portfolio improves its risk-return profile.

The academic literature has essentially focused on two complementary issues: determinants of wine prices (static perspective) and returns to an investment in wine (dynamic perspective). On the one hand, since the early 1990s, the literature has acquired a precise understanding of wine's specificities and their impact on prices. The influence of natural endowments, climatic conditions during the growing season, the variety of grapes used in the blend, winemaking techniques, the producer's reputation, and expert rating, among others, have been examined in numerous studies.[1] On the other hand, the literature on wine price dynamics is less extensive and generally more recent.[2] While this literature has exploited the knowledge gathered on wine prices and their determinants, it has not considered the very specificities of the wine market. The literature mostly evaluates the performance of an investment in wine as if wine were a traditional financial asset traded on a financial market.[3] Unfortunately, wine is not a conventional asset (Baumol, 1986). Indeed, wine is a particular good that, similar to other emotional assets, does not offer cash flows, and is very sensitive to human behavior. The market for fine wines is also structured in a complex manner and suffers from multiple sources of inefficiencies that make it relatively illiquid. Moreover, it is an easily transportable good that has gained a broad and global clientele making it prone to currency fluctuations.

[1] See, e.g., Byron and Ashenfelter (1995), Combris, Lecocq, and Visser (1997), Landon and Smith (1997), Combris, Lecocq, and Visser (2000), Jones and Storchmann (2001), Schamel and Anderson (2003), Ashenfelter (2008), and Oczkowski and Doucouliagos (2015).

[2] Two important early contributions are Krasker (1979) and Jaeger (1981). More recent contributions include Fogarty (2006), Fogarty (2010), Storchmann (2012), Masset and Weisskopf (2015), Faye, Le Fur, and Prat (2015), Dimson, Rousseau, and Spaenjers (2015), and Masset and Weisskopf (2018a).

[3] For instance, the two aforementioned studies of Sanning et al. (2008) and Masset and Henderson (2010) use a relatively limited dataset and apply conventional financial tools (e.g., asset pricing models and portfolio optimization procedures) without adjusting them for the illiquidity on the wine market.

The limitations from previous studies and, in particular, their failure to account for illiquidity and exchange rate movements cast doubt on the actual investment performance of fine wine. In financial economics, the impact currency risk has on companies and investors has a longstanding history (Adler & Dumas, 1984). Illiquidity is also increasingly recognized as a critical phenomenon that has significant consequences for investors.[4] In particular, both types of risk may result in difficulties in correctly estimating an asset's return and risk. In the case of illiquidity, it may even induce biased comparisons between illiquid investments and other asset classes if price reactions occur with a delay. Lastly, several articles demonstrate that investors perceive currency fluctuations and illiquidity as relevant sources of risk when developing their return expectations (see, e.g., Pástor and Stambaugh (2003), Acharya and Pedersen (2005), De Santis and Gerard (1998), Lustig, Roussanov, and Verdelhan (2011)). Therefore, the required rate of return on assets that are sensitive to market-wide liquidity and currency shocks may include different risk premia. These issues are yet to be considered within the context of fine wines.

In this paper, we devote particular attention to the effect of illiquidity and exchange rate movements on fine wines. To develop a more accurate estimation of the real performance that wine may offer, we proceed as follows. First, we exploit an original and comprehensive dataset containing the vast majority of transactions on the world's most sought-after wines, namely the Bordeaux First Growths. Our dataset contains hammer prices from leading auction houses located across the globe over 2003–2014. This study's wines represent a significant part of the overall wine market in terms of transaction numbers and values. For instance, in 2014, they represented around 80% of all transactions on the trading platform provided by Liv-ex.[5] To the best of our knowledge, we are the first to use such an in-depth dataset, which enables us to precisely examine the determinants of wine prices and, more importantly, to estimate a very accurate wine index. Second, we use a methodology that controls for wine market illiquidity. Following Scholes and Williams (1977) and Dimson (1979), we calculate a total beta estimate as the sum of current and lagged factor exposures. We furthermore study different sampling frequencies better to understand the linkage effects between wine and stock markets. Lower frequency sampling of data reduces the issue induced by nonsynchronous changes in the wine and stock prices. Third, we recognize the sources of risk that illiquidity and exchange rates may represent to investors. Therefore, we add a liquidity and two currency risk premia to the conventional capital asset pricing model (CAPM). We follow the approach of Pástor and Stambaugh (2003) to develop a liquidity-augmented CAPM and, in a

[4] See Amihud, Mendelson, and Pedersen (2006) for a survey of the literature on illiquidity and its consequences on asset prices.
[5] Liv-ex provides fine wine indices and valuation tools.

second step, add the currency factors proposed by Lustig et al. (2011) to put forward a liquidity and FX-augmented CAPM.

While prior research generally supports the claim that investments in fine wines display limited risk (thanks to the limited exposure to market risk) and generate positive abnormal returns, our results suggest a different story. We first show that fine wines are relatively risky, with an annualized volatility of 25% to 30%. The diversification benefits of fine wine are also less appealing than previously reported findings. Even within a simple framework based on the CAPM, fine wines unequivocally trigger a positive market risk premium. Nonetheless, fine wines retain a beta of less than 1.00. Still, recent data combined with a methodology adapted to the analysis of an illiquid asset leads to a substantial decline in the estimated abnormal returns. That is, although alpha is still positive, it loses its significance. Finally, we establish that a large fraction of the returns to fine wines is due to liquidity and currency risk. Fine wines' exposure to these two sources of risk is positive and economically and often statistically significant. Thus, the liquidity and currency exposure further reduces fine wines' alpha, which becomes barely distinguishable from zero and remains statistically insignificant.

This paper contributes to the existing literature in several dimensions. First and foremost, our paper helps improve our comprehension of a particular type of collectible—fine wine—that has increased in importance over the last two decades. By their very nature (the existence of tens of thousands of bottles of the identical wine), they are the most actively traded collectible. Therefore, the present study should provide relevant insights into addressing other collectibles' risk features, such as paintings, classic cars, stamps, or watches. We find that illiquidity and currency risk exposure are significant in the fine wine market. It must be considered when assessing the performance and risks of an investment in fine wine, especially when comparing them with other asset classes. Our results further indicate that wine investments are riskier than usually thought. Earning an abnormal return on the wine market is far more complicated than academics and practitioners have frequently suggested. This constitutes an important extension to many studies analyzing the risk and return characteristics of collectibles in a classic CAPM or Fama- French framework and which do not account for the specificities of these assets (Mei & Moses, 2002; Sanning et al., 2008).

Second, we use an in-depth database on fine wine transactions, which contains nearly all transactions on the sampled wines and period. Most past studies concentrated on data from a single auction house (Fogarty & Sadler, 2014; Masset & Weisskopf, 2018a), which is not ideal as auction houses and locations affect wine prices (Masset, Weisskopf, Faye, & Le Fur, 2016). Thus they are not able to represent the global outreach and overall liquidity of the wine market. Other studies use wine indices provided by Liv-ex (Aytaç, Coqueret, & Mandou, 2018; Ben Ameur & Le Fur, 2020), which, however, is problematic to make precise inferences on risk attributes of wine (Masset & Weisskopf, 2018b). Our sample allows us to alleviate these issues and provides other advantages that we use in this paper. We can trigger the way wine generally reacts to liquidity and exchange rate fluctuations and how sub-markets behave. As for many other collectibles, wine is not uniform and attracts a diverse clientele that will look for specific characteristics. This should affect the market depth and, thus, the liquidity of the sub-market. It also affects currency exposure as wine investors may not be located at the same place as a collector or amateur.

Third, this paper also advances our understanding of the importance of common risk factors for non-traditional asset classes. The fact that we use a liquidity risk premium whose calculation is based on stock returns is important to note (Pástor & Stambaugh, 2003). Also, the strong linkage of fine wine returns compensating for currency risk is of interest to an asset that can easily be traded worldwide with very few restrictions. Through a set of robustness tests, we also assess the explanatory power of other common risk factors[6] and show that only the Fama-French small-minus-big (SMB) factor appears as relevant in the context of wine investments. Given that small companies tend to be less liquid than big companies, the SMB factor is also indirectly related to liquidity risk. Our results suggest that market, liquidity, and currency risks affect various asset classes and are not specific to stocks. Moreover and given that fine wines are among the most actively traded collectibles and not necessarily the easiest to ship, it is highly probable that other collectibles are at least as sensitive to both risks. In this, we expand prior evidence by Dimson and Spaenjers (2011) and Dimson et al. (2015) on liquidity issues in the market for stamps and fine wine.

The next section surveys the relevant literature on wine as an investment and liquidity. Section 3 is dedicated to the presentation of our dataset and its specificities. In section 4, we expose the approach we use to construct wine indices and assess a wine investment's performance. In section 5, we present and analyze the results. Section 6 concludes.

[6] We consider the small-minus-big (SMB) and high-minus-low (HML) factors of Fama and French (1993), the momentum factor (MOM) of Carhart (1997), and the hedge fund benchmarks of Fung and Hsieh (2001), Fung and Hsieh (2002), and Fung and Hsieh (2004).

2 Wine investment, liquidity, and exchange rates

2.1 Wine as an investment

Existing literature suggests that it is difficult to precisely assess the potential of fine wine as an investment.[7] Indeed, the results from various studies contrast with one another and sometimes even conflict. Most of these discrepancies can be explained by differing research designs or samples and are, thus, not directly comparable. First studies were mostly restricted to the returns fine wine, especially from Bordeaux, could offer on their own. Though the framework appears clear, findings still strongly vary in magnitude, depending on the sample period considered. Krasker (1979) concludes that red Bordeaux wines and Californian Cabernet Sauvignons have not significantly outperformed a riskless asset in the early 1970s, while Jaeger (1981), considering an extended investment period, observes that these wines strongly outperformed U.S. Treasury bills. Di Vittorio and Ginsburgh (1996) find a price increase over the period 1981 to 1985, but a price decline in the second half of the 1980s for Bordeaux wines. Jones and Storchmann (2001) arrive at a similar 3% yearly return for the period 1980 to 1994. This return magnitude is matched by Byron and Ashenfelter (1995), reporting a real return of 3.9% p.a. between 1952 and 1980 for Penfold's Grange from Australia. Finally, Burton and Jacobsen (2001), for a similar investment period (1986 to 1996), find close to double the returns of Jones and Storchmann (2001), leading to an overperformance compared to Treasury bonds, but not to U.S. equity. Dimson et al. (2015) investigate the price evolution of a smaller set of five Bordeaux wines from 1900 to 2012. They conclude that in the long-run, wine performs as well as equity and outperforms other collectibles.

Following these estimates on the stand-alone returns to fine wine, literature has evolved towards more comprehensive results by contemplating additional production zones and its role in the context of an investor's portfolio and asset pricing models. Evidence is, overall, coherent and suggests that fine wine is a good investment and should be added to an investor's portfolio. Sanning et al. (2008) report that Bordeaux wines delivered large abnormal returns (alpha) while retaining a low exposure to systematic risk factors in a CAPM and Fama and French (1993) three-factor model. Fogarty (2006), Fogarty (2010), or Masset and Henderson (2010) confirm the attractive risk-return profile and low correlations of wine with equity in an investor's portfolio. These results are further extended by Masset and Weisskopf (2018a), showing that wine produced outside Bordeaux also outpaced the U.S. stock market on a risk-adjusted basis and were remarkably resilient during economic and financial crises. Kourtis, Markellos, and Psychoyios (2012) find similar conclusions

[7] Table 1 presents a more comprehensive overview of the literature on wine investments. For the interested reader Le Fur and Outreville (2019) and Fogarty and Sadler (2014) provide comprehensive reviews of the literature.

on the diversification benefits of wine from alternative production areas. Masset, Weisskopf, and Fauchery (2020) further confirm these findings by studying wines from different central-European regions on the verge of becoming investable assets. On the contrary, Dimson et al. (2015) indicate that controlling for illiquidity in the wine market, wines are positively correlated with stocks and provide a higher systematic risk than reported in previous studies.

Finally, studies have also turned to cointegration and volatility transmission analyses for different wine sub-markets and in relation with other asset classes to analyze potential diversification benefits. Findings reported in Faye et al. (2015), Introvigne, Bacchiocchi, and Vandone (2017), E. Bouri, Gupta, Wong, and Zhu (2018), or Ben Ameur and Le Fur (2020) largely depend on the asset classes, wines and methods considered and range from positive diversification benefits to wine only offering limited advantages. Overall, wine appears to be a good investment. Still, literature has not yet entirely incorporated the wine market's specificities, such as its global trading and relatively low liquidity compared to financial assets.

2.2 Wine as an illiquid and globalized asset: Causes and consequences

Illiquidity in the wine market is mostly caused by the market's organization and the asset's nature. Fine wines are exchanged through multiple channels and at various locations spread throughout the world. This absence of a single marketplace hinders the aggregation to a unique price for each wine (Cardebat, Faye, Le Fur, & Storchmann, 2017). Numerous market frictions worsen the situation. Apart from direct trading costs, one faces substantial shipping, storage, and insurance fees, search costs, and inventory risk due to changing customer preferences. The fine wine market remains somewhat opaque and suffers from considerable information asymmetries (Onur, Bruwer, & Lockshin, 2020). For instance, for buyers to gain precise information about producers and brokers' remaining inventories is almost impossible. In some circumstances, it may even be complicated to collect information about the quality of a specific wine, which is why experts, such as Robert Parker and James Suckling, are very influential regarding wine prices (Cardebat, Figuet, & Paroissien, 2014; Masset, Weisskopf, & Cossutta, 2015).

The specificities of wine and, in particular, its intrinsic heterogeneity add complexity to the market and, thereby, further reduce its liquidity. Its nature also makes wine prone to human biases (Aytaç et al., 2018; Fernandez-Perez, Frijns, Tourani-Rad, & Weisskopf, 2019). In particular, its valuation is complex and highly subjective because it does not deliver any cash flow. Finally, the limited production restricts the maximal quantity of each wine that is available for exchange. This quantity decreases with time as most wine buyers purchase wine for consumption purposes and not for investment; therefore, each wine has a relatively low free-float as consumers do not actively trade their wine inventory. The relatively sparse number of wine auctions per year further decreases the turnover of a given wine bottle.

A lack of liquidity directly affects asset returns and their statistical features. Many wines do not trade regularly and, hence, their prices often remain constant for several weeks. Thus, infrequent trading activity generates stale prices and can further underestimate volatility and spurious positive autocorrelation even at long lags if not adequately taken into account (Masset & Weisskopf, 2018b). Like other illiquid assets, fine wines also tend to react much less rapidly to new information than stocks or bonds (Masset & Weisskopf, 2018b). This non-synchronicity needs to be considered. Otherwise, the cross-relationship of wine with other asset classes and, in particular, its beta is likely to be severely underestimated.

The increased internationalization of the fine wine market is primarily due to the emergence of a new customer base. Until the 1970s, wine was predominantly produced and consumed in Western Europe, with Bordeaux and London as central market places. In the 1980s, the market expanded to North America, creating new trading hubs in New York and Chicago. Finally, in the 2000s, an Asian and predominantly Chinese clientele got interested in fine wine, which led to an important Asian wine hub in Hong Kong (Masset et al., 2016). This was accompanied by the emergence of new customers in the form of wine investors and wine funds who perceived the wine market, not for collection or consumption purposes but to trade it similarly to a financial asset (Masset & Weisskopf, 2015). This evolution should trigger a stronger relationship between the wine market and currency fluctuations. The production and the primary market mainly evolve in a euro-denominated environment, while the clientele and the secondary market trades in various currencies.

Evidence on the impact of foreign exchange (FX) rates on the wine market is relatively scarce and examines currencies' role on demand for fine wine. Cardebat and Figuet (2019) show that French wine exports fell due to the euro's appreciation against the USD and the GBP. However, the share of high-end wines has increased, as customers responded by quality sorting following the euro's appreciation. Jiao (2017) finds evidence that emerging markets' demand for wine and the USD's weakening positively impacted Bordeaux wine prices. However, since 2011, the depreciation of several currencies has harmed the wine market. Anderson and Wittwer (2018) also find a linkage between the GBP and wine markets following Brexit. A notable exception in the literature on wine markets and exchange rates comes from Erdős and Ormos (2013). In an analysis of the wine market's efficiency, they suggest the existence of currency risk on this market. They indicate that U.S. wine investors face more substantial currency exposure than U.K. investors.

2.3 Research agenda

The previous discussion indicates that considering an extensive database to examine the issues induced by the wine market's illiquidity and its international scope is important. The use of appropriate methods to estimate reliable indices and assess their features in terms of market, liquidity, and currency risk is also essential. The literature on equity markets proposes solutions to these different issues, which we will apply to the market for fine wine.

Exposure to market risk **and delayed reaction:** in a first step, we will study the exposure of fine wine to market movements using a classic CAPM framework that we will enhance in the vein of Dimson (1979) to allow for delayed reactions on the wine market.

Liquidity risk: illiquidity-averse investors will trigger a liquidity risk premium for assets that are more sensitive to liquidity shocks. Thus, in a second step, we enhance the market model by the liquidity factor proposed by Pástor and Stambaugh (2003) to control for the wine market's illiquidity.

Currency risk: this market has further gained an increasing international scope, making it more prone to currency fluctuations. Therefore, we use the currency risk factors proposed by Lustig et al. (2011) to better understand if wine is exposed to this source of risk.

Risk premia: in the last step, we use a Fama-MacBeth approach to examine whether a risk premium related to the exposure of fine wines to the different risk factors exists.

3 Data

Our sample contains hammer prices for the five *First Growth* wines from the Médoc and Graves regions plus Château Mission Haut-Brion,[8] the four *First Growth A* from Saint-Emilion, the only *Superior First Growth* from Sauternes, and the three best wines from Pomerol (see table 2 for details).[9] Liv-ex estimates that these sought-after and popular wines among collectors, investors, and wine funds account for close to 80% of the fine wine market.[10] We consider only vintages from 1945 to 2010 because older vintages may suffer from an antique effect (see Krasker (1979) and Jaeger

[8] While not officially classified as First Growth, this wine is considered to achieve the same level of quality as its neighbor, Château Haut-Brion, which is ranked as First Growth.

[9] The terms "First Growth," "First Growth A," and "Superior First Growth" refer to wines that have been ranked at the top of the classification of Bordeaux wines. In the Médoc and Graves regions, and in Sauternes, this classification has remained almost similar since 1855 (only Château Mouton Rothschild was upgraded in 1973). In Saint-Emilion, the classification is updated every 10 years (in 2012, Angélus and Pavie have been upgraded from "First Growth B" to "First Growth A"). In Pomerol, no official classification exists but the hierarchy is nevertheless relatively clear, with Pétrus, Lafleur, and Le Pin widely considered as the best wines from this appellation.

[10] https://www.liv-ex.com/2019/12/broadening-fine-wine-market/.

(1981)).[11] The use of auction hammer prices ensures that the prices recorded correspond to genuine transactions.[12] Our dataset includes almost all transactions involving the fourteen wines presented above and is thereby much deeper than the samples used in previous research. The large number of observations is crucial as it enables us to come up with detailed indices.

3.1 Presentation of the dataset

The sample consists of hammer prices from all major auction houses globally (Acker Merrall & Condit, Bonham's, Christie's, Edward Roberts, Hart Davis Hart, Morell's, Sotheby's, and Zachy's).[13] We discard mixed lots and only consider lots with identical château-vintage pairs (i.e., identical wines). Our final dataset contains observations for 634 unique château–vintage couples and consists of 152,484 lots representing a total of 1,382,601 bottles (only 750 ml) sold between 2003 and 2014.

It is necessary to distinguish the respective vintage for each château as quality can vary strongly from one vintage to another. For example, Château Mouton Rothschild 2000 and Château Mouton Rothschild 2001, although from the same producer, are two distinctive wines that sell at distinct prices. The average price in 2014 for a bottle of Mouton Rothschild 2000 was close to USD1,200, while the price of the 2001 vintage was less than USD400. We use Parker scores to control for differences in quality (in this specific example, 96 and 89 points). Robert Parker is the most prominent wine expert over our sample period (Cardebat et al., 2014; Masset et al., 2015). We obtain Parker scores for 496 wines (covering 97% of all transactions) with an average Parker score of 94.5 (on a range between 50 and 100). For each lot, we also collect information on the number of bottles auctioned. Ceteris paribus, there should be a negative relationship between the number of bottles in a lot and the selling price. A positive relationship between the auctioning of bottles in an original wooden case (henceforth, OWC) and hammer prices has also been reported. The presence of the OWC hints at better storage conditions and reduces the uncertainty of purchasing counterfeits. In our dataset, approximately 57% of all lots auctioned consist of cases of twelve bottles and 12% of cases of six bottles.

---

[11] Very old wines have different characteristics than young wines. Notably, they tend to be more difficult to taste and appreciate. Moreover, when buying such a wine, a significant probability exists that it is no longer drinkable. As such, those wines attract a rather different clientele than younger wines.

[12] Using listed prices from merchants can lead to substantial biases for two reasons. First, they do not necessarily correspond to effective transaction prices. Second, the number of bottles available at a given price is generally not precisely known.

[13] The hammer price includes the relevant buyers' premium but is exclusive of sales tax and VAT.

Data on stock markets, exchange rates, and interest rates are from ThomsonReuters Datastream. We also collect data on various risk factors, including the Pástor and Stambaugh (2003) liquidity factor[14] and the Lustig et al. (2011) currency factors.[15]

3.2 Descriptive statistics

In Table 2, we report the average price (Panel A) and the number of trades (Panel B) by Château and year. As is apparent from Panel A, wines from the same appellation trade at prices in the same order of magnitude. This price homogeneity is stronger in the appellations from the Gironde's left bank (Médoc and Graves) than elsewhere in Bordeaux. In Saint-Emilion, the prices of Angélus and Pavie, both upgraded in 2012, have yet to catch up with the two historic First Growths A (Ausone and Cheval Blanc) from this appellation. Although wines from Pomerol and, more specifically, Pétrus and Le Pin, are not officially ranked as First Growths, they nevertheless tend to be the most expensive in the entire Bordeaux area. This observation can be attributed to a rarity effect as wines from Pomerol are much scarcer (with productions from 6,000 to no more than 30,000 bottles per year) than their counterparts from Saint-Emilion (70,000 to 120,000) and the left bank (70,000 to 300,000).[16]

< Insert Table 2 here >

Most wines have experienced a strong price increase between 2003 and 2011, which can be explained by a string of great vintages (2005, 2009, and 2010) and the massive arrival of new customers from BRIC (Brazil, Russia, India, and China) countries and, in particular, China. Since mid-2011, prices have adjusted. These patterns are especially pronounced for Lafite Rothschild, whose prices exhibited a bubble-like dynamic, with an increase of 300% to 400% between 2005 and 2011, followed by a 40% decline in 2011–2014. Ausone has also experienced a substantial price increase during the last fifteen years, a phenomenon that can be explained by the strong quality improvement this estate has undergone since the 1980s. The average Parker score for Ausone has progressed from 82.4 in the eighties to 89.8 in the nineties and 97.3 in the new century's first decade. Angélus and Pavie have steadily increased since 2003 and more rapidly since their upgrade to First Growth A status in 2012.

[14] http://faculty.chicagobooth.edu/lubos.pastor/research/liq_data_1962_2014.txt.
[15] http://web.mit.edu/adrienv/www/Data.html.
[16] These figures are approximations based on various sources. Moreover, note that production can vary from one year to another depending on weather conditions.

Panel B reports the number of trades per year for each wine. It directly relates to the trading probability. Therefore, this measure resembles the liquidity proxy used by Liu (2006), who considers non-trading probability and turnover rate. In general, wines from the Médoc and, more particularly, Mouton-Rothschild and Lafite-Rothschild are the most liquid. Pétrus and Cheval-Blanc are also traded regularly, but the other wines from Saint-Emilion and Pomerol tend to show up at auctions much less frequently. The higher liquidity of wines from the Médoc and Graves regions is not surprising given that these estates produce more bottles than their counterparts. Panel B also illustrates the tremendous increase in the wine market's trading activity between 2003 and 2011. Since 2011, although still significantly higher than its 2003 level, trading activity has substantially decreased. This pattern is especially pronounced for Lafite Rothschild.

< Insert Figure 1 here >

Figure 1 assesses the linkage in liquidity, using the aggregated liquidity measure computed by Pástor and Stambaugh (2003), between the wine market and the U.S. equity market. It appears that both markets, while being distinctly different from each other, still display common patterns in terms of liquidity. The simple 3-months moving average follows a similar evolution from 2003 to 2009 and 2012 to 2013. From 2010 to 2011, the equity market liquidity has stabilized to pre-financial crisis levels again, while the liquidity on the wine market strongly increases. In 2014, the wine market liquidity tends to drop while equity markets again remain relatively stable. Thus, both markets appear to, overall, show common liquidity patterns.

< Insert Table 3 here >

Table 3 shows the average price, the number of trades, and Robert Parker score per vintage calculated during 2014.[17] The trading activity figures report that buyer interest for some vintages, such as 1982, 1990, or 2000, is stronger than for others, such as 1981, 1991, or 1999. Quality differentials can explain this pattern. This is evidenced by the average Parker scores for the various wines in these vintages (97.3, 96.1, and 98.6 for 1982, 1990, and 2000; 87.2, 86.7, and 93.7 for 1981, 1991, and 1999). Other great vintages comprise 1945 (great and historically highly symbolic), 1959,

[17] Similar statistics for years 2003 to 2013 are available from the authors on request.

1961, and lately 2005, 2009, and 2010. Of course, vintages of superior quality trigger price premiums. For example, the average price for a bottle of 1982 in 2014 was slightly lower than USD1,600, while First Growths from 1981 traded on average close to USD500.

< Insert Table 4 here >

Table 4 displays the average price, the number of trades, Robert Parker scores, and the percentage of wines traded which are older than 20 years for each geographical region. The wine market has become truly global with auctions' appearance by all major auction houses in Asia (mainly Hong Kong) in 2008. Since then, Asia has surpassed Europe in the number of trades and has established itself as a new hub for wine with North America. The price evolution across all three locations is similar, indicating some form of market integration. However, the wine market also displays some segmentation, with the highest prices achieved mainly in Asia, while those at European auctions fetch the lowest prices. This segmentation is also apparent in the type of wines sold on the three continents. In Asia, it is mainly younger vintages with very high scores that are traded. In North America, older wines with good scores. Europe remains more diversified in its approach as wines with many different characteristics change hands. Overall, the wine market has increasingly internationalized, and market participants take the opportunity to trade on different continents depending on preferences and arbitrage considerations linked to market inefficiencies and currency movements.

4 Methodology

This section follows the outline presented in the research agenda in section 2.3. It first describes the construction of a series of wine indices whose purpose is to reflect a typical wine investor's portfolio's performance. A second step analyzes how to assess the risk-return features of a wine investment and proposes two techniques to overcome the problem induced by the slow adjustment of wine prices to new information. We then analyze whether fine wines are exposed to illiquidity and currency risk. Finally, we run Fama-MacBeth regressions to determine if exposure to the aforementioned sources of risk is rewarded by a risk premium.

4.1 Index construction

Index providers, such as Liv-ex (in the U.K.) or Idealwine (in France), calculate their indices based on weighted average prices of their components. Its simplicity makes it convenient, but its inability to account for wine market illiquidity makes it prone to biases. In academic research, most authors favor the hedonic regression (henceforth, H.R.) (see, e.g., Jones and Storchmann (2001) and Fogarty (2006)) or the repeat-sales regression approach (RSR) (see, e.g., Burton and Jacobsen (2001) and Dimson et al. (2015)).[18] Both approaches can resolve the issues related to the heterogeneity of exchanged wines and the overall wine market illiquidity. The main difference between the H.R. and RSR approaches lies in the fact that the former aims to model wine prices explicitly. At the same time, the latter only considers the *returns* between repeated transactions of the same wine. As such, the main advantage of the RSR over the H.R. is that it does not require the explicit identification of all potential price determinants. However, this advantage comes at a cost: as this approach only uses repeated transactions, a substantial number of observations might be lost. In this paper, we opt for the H.R. approach as it exploits all observations and allows to control for the influence on the hammer price from a variety of attributes.[19]

The H.R. was initially proposed by Rosen (1974) and has often been applied in the context of assets that trade only infrequently, such as real estate (Campbell, Giglio, & Pathak, 2011) or artworks (Chanel, Gérard-Varet, & Ginsburgh, 1996). This approach assumes that its characteristics determine a wine bottle's price (e.g., varietal used, vintage, reputation) and the implicit value attached to each of them. The functional form of a hedonic regression is in a linear semi-log form:[20]

$$p_i = \beta_0 + \sum_{j=1}^{J} \beta_j x_{ij} + \varepsilon_i \qquad [1]$$

where p_i is the natural logarithm of the price of lot $i = \{1,2,\dots,N\}$; x_{ij} and contains information on the attributes of lot i and the regression coefficients $\beta_j, j = \{1,2,\dots,J\}$ correspond to the implicit value attached to each specific wine attribute. These attributes may include variables specific to the respective wine, such as producer name, vintage, expert score, and specific variables,

[18] Other methods encountered are the hybrid method (Fogarty & Jones, 2011) and the average or winsorized average of returns Sanning et al. (2008) and Masset and Henderson (2010)).
[19] As a robustness test, we also estimate an index using the RSR approach. The results remain qualitatively similar (see section 5.5 for more details).
[20] The semi-log form is the most frequently encountered specification for hedonic regressions (see, e.g., Oczkowski and Doucouliagos (2015)).

like the existence of an original wooden case or the number of bottles in a lot. Equation [1] is appropriate for studying price mechanics at a particular moment in time. If the sample under investigation includes prices recorded at different moments, equation [1] can be further extended to account for this feature:

$$p_i = \beta_0 + \sum_{j=1}^{J} \beta_j x_{ij} + \sum_{t=1}^{T} \theta_t d_{it} + \varepsilon_i \qquad [2]$$

where d_{it} is a dummy variable taking the value one if there was a transaction for wine i in time t and 0 otherwise. The matrix coefficients, pooled into vector θ, constitute the index levels (expressed as natural logarithms) at the respective dates $t = (1, \ldots, T)$. Consequently, the coefficient exponentials, $\exp(\hat{\theta})$, with $\hat{\theta}$ being the fitted regression coefficients from equation [2] can be used to construct a wine price index following the equation

$$Wine\ Index_t = \exp(\hat{\theta}_t) * Wine\ Index_1 \qquad [3]$$

When estimating equation [2], one has to remove a time dummy variable to avoid multicollinearity issues. It is common to remove the dummy that corresponds to the first date in the sample. This is convenient because this implies that the fitted $\hat{\theta}_t$ coefficients can then be related to the return of the index between the initial period and t. One can set the initial level of the index, $Wine\ Index_1$, equal to an arbitrary value (usually 100 or 1,000).

4.2 Specifications used in this paper

Based on equation [2], we use three specifications, which include three different sets of explanatory variables. The first specification focuses on the effect of age on wine prices. The second specification controls for the interaction effect of age and the overall quality of a specific vintage. Finally, the third specification is more detailed because it assesses the value attached to each vintage from 1945 to 2010. Table 5 lists the variables included in each specification and is described in more detail hereafter.

< Insert Table 5 here >

A. Variables specific to the wine auctioned: We include variables such as château, vintage, vintage quality, age, and expert ratings to control for the different sources of price variations of auctioned wines. For instance, Bordeaux's varying weather conditions can lead to significant price differences (Cardebat et al., 2014). Similarly, some châteaux may profit from better natural endowments or have a better reputation, affecting prices upwards (Malter, 2014). We use Parker scores to model the relation between quality and price. We also include squared Parker scores in our specification to control for potential non-linearity effects between wine scores and prices. Finally, we consider the age of a wine as a determinant of its price. One expects a positive relationship between age and price due to increasing scarcity and quality improvement throughout the aging process. The age variable is collinear with the vintage and time-of-sale dummies. Thus, we use the age variable only in the first two specifications, which does not include vintage dummies. We also add a variable to account for the interaction between vintage quality and age in the second specification. A wine from an excellent vintage is likely to benefit more from the aging process than a wine from an average vintage. We use five dummy variables to account for a vintage's overall quality (from poor to great).[21]

B. Variables specific to a particular transaction: Several non-wine features related to the auctions may affect hammer prices. For example, fees, or shipping costs may influence prices at distinctive auction houses or locations (Cardebat et al., 2017). Some auction houses may also be more reputable than others. We include auction house and location dummies in the regression to take these effects into account and add the number of bottles per lot for potential quantity discounts on the price. Wines in an OWC may trigger a premium due to a reduction in the probability of purchasing a counterfeit. Therefore, we include an additional dummy variable with the value 1 for wines auctioned in OWC and 0 otherwise. We consider two dummy variables to distinguish between OWCs of six and 12 bottles.

4.3 Performance and risk analysis

4.3.1 Delayed reaction

Illiquidity manifests itself in low trading activity characterized by a limited number of trades. The methodology previously presented aims to extract as much information as possible from

[21] The quality of each vintage is estimated on the basis of two complementary sources: Idealwine (www.idealwine.com) and Robert Parker's vintage chart (http://www.robertparker.com).

observed prices to determine a precise estimation of wine index levels. However, this lack of liquidity may also result in delayed reactions of the wine market to economic and financial news, which may underestimate the contemporaneous relation between fine wines and other assets. To analyze the performance and, more specifically, the risk features of an investment in fine wines, we resort to the Capital Asset Pricing Model (CAPM) and make some adjustments to the classic approach to account for the effect of illiquidity and currencies on the wine market.

The classic CAPM (Lintner, 1965; Mossin, 1966; Sharpe, 1964) decomposes observed excess returns into three parts: a constant (Jensen (1968) alpha), a risk-premium, and a residual, as follows:

$$R_{w,t} - r_{f,t} = \alpha_w + \beta_w\left(R_{M,t} - r_{f,t}\right) + \varepsilon_t \qquad [4]$$

$R_{w,t}$, $R_{M,t}$, and $r_{f,t}$ are the return on the wine index, the return on a reference stock market index, and the risk-free rate at time t. Beta (β_w) captures the systematic risk involved in an investment in fine wine, while alpha (α_w) provides an estimate of its abnormal return. Alpha has gained a special status in the context of alternative investments. This kind of investment aims to generate returns that do not depend on market conditions; such returns are considered abnormal and quantified by the alpha.

To account for a potential lagged response of the wine market to changes in the economic and financial conditions, we proceed as follows. We first estimate equation [4] using both monthly and quarterly data. The delayed reaction is likely to play a substantially lesser role when low-frequency data are used to estimate the beta. To test whether beta is significantly different using monthly or quarterly data, we use a bootstrap approach to simulate 100,000 random shuffles of the initial wine and factor returns. We here test for the stability of the relationship (Chow test), the stationarity of the returns, and use an EGARCH process to account for time-varying variance.[22]

A second approach involves adding lagged market returns to specification [4]. This approach, initially suggested by Scholes and Williams (1977) and Dimson (1979), has been applied in Dimson and Spaenjers (2011) and Dimson et al. (2015) in the context of collectible stamps and fine wines, respectively.

$$R_{w,t} - r_{f,t} = \alpha_w + \sum_{j=0}^{J} \beta_{w,j}\left(R_{M,t-j} - r_{f,t}\right) + \varepsilon \qquad [5]$$

The *total* beta of a wine w can then be obtained by summing contemporaneous and lagged beta estimates, i.e., $\beta_w = \sum_{j=0}^{J} \beta_{w,j}$ with J representing the number of lagged market returns to be used

[22] We use an EGARCH model to account for the asymmetric relation between returns and volatility, which translates into a negative skewness for the various risk factors and a positive one for the fine wine indices.

in the estimation. In the case of non-zero autocorrelation in the lags 1 to J of the market returns, we need to adjust the total beta by dividing it with a denominator that accounts for this autocorrelation structure.

4.3.2 Illiquidity risk

Illiquidity is a complex phenomenon that affects asset returns' statistical properties and the cost of trading those assets and, more importantly, their risk. Liquidity shocks may impede investors' ability to trade and may thereby considerably impact their utility. Illiquid assets, such as fine wines and other collectibles, are likely to be particularly sensitive to this source of risk. Therefore, we use the Pástor and Stambaugh (2003) liquidity-augmented version of the CAPM to determine whether investors are rewarded by a liquidity risk premium when they invest in fine wine. They first estimate a non-traded liquidity factor (denoted L_t) that tracks the innovations in the level of liquidity at the market level. They then form portfolios based on the sensitivity of the various stocks to L_t. Finally, they subtract the returns on the portfolio containing the stocks that are the least sensitive to liquidity from the one with the most sensitive stocks. The difference in returns between these two portfolios corresponds to the traded liquidity factor, LIQ_t. This factor can then be added to the conventional CAPM, thereby leading to the following model:

$$R_{w,t} - r_{f,t} = \alpha_w + \beta_w\left(R_{M,t} - r_{f,t}\right) + \lambda_w LIQ_t + \varepsilon_t. \qquad [6]$$

LIQ_t is the liquidity risk factor and λ_w quantifies the exposure of fine wine to this source of risk. Equation [6] can be extended by adding lagged realizations of the stock market and liquidity premia:

$$R_{w,t} - r_{f,t} = \alpha_w + \sum_{j=0}^{J} \beta_{w,j}\left(R_{M,t-j} - r_{f,t}\right) + \sum_{k=0}^{K} \lambda_{w,k} LIQ_{t-k} + \varepsilon_t. \qquad [7]$$

where J and K are the number of lagged market returns and lagged realizations of the liquidity factor used in the estimation.

4.3.3 Currency risk

Exchange rates impact the properties of asset returns and their risk. For example, Glück, Hübel, and Scholz (2020) show the importance of taking currencies into account when using factor models in asset pricing and the biases omitting to do so. Currency fluctuations may also influence an investor's trading costs and benefits. Assets, such as fine wines or collectibles more generally, which are easily movable, tradable throughout the world, and of interest to a global investor base are likely to be sensitive to this source of risk. Therefore, we use the Lustig et al. (2011) currency factors, RX and HML_{FX}, that we add to the liquidity-augmented CAPM to determine whether investors are rewarded for their exposure to currency risks when they invest in fine wine.

The two currency factors proposed by Lustig et al. (2011) include the average currency excess return (RX) of an investor buying non-US currencies forward on the market. The second factor constitutes the difference in returns between the top and bottom currency portfolios (HML_{FX}). It reflects a strategy of going long currencies in high-interest countries and shorting those currencies with low interest rates. These two factors can be added to an asset pricing model, thereby leading to the following model in our case:

$$R_{w,t} - r_{f,t} = \alpha_w + \beta_w(R_{M,t} - r_{f,t}) + \lambda_w LIQ_t + \gamma_w RX_t + \theta_w HML_t + \varepsilon_t. \quad [8]$$

RX_t and HML_t are the currency risk factors and γ_w and θ_w quantify the exposure of fine wine to this source of risk. Equation [8] can be extended by adding lagged realizations of the stock market, liquidity, and currency premia:

$$R_{w,t} - r_{f,t} = \alpha_w + \sum_{j=0}^{J} \beta_{w,j}(R_{M,t-j} - r_{f,t}) + \sum_{k=0}^{K} \lambda_{w,k} LIQ_{t-k} +$$

$$\sum_{k=0}^{K} \gamma_{w,k} RX_{t-k} + \sum_{k=0}^{K} \theta_{w,k} HML_{t-k} + \varepsilon_t. \quad [9]$$

where J and K are the number of lagged market returns and lagged realizations of the liquidity and currency factors used in the estimation.

4.3.4 Cross-sectional evidence

To calculate the effective risk premia and validate whether an adequate compensation for the exposure of wine to the risk factors exists, we use the Fama and MacBeth (1973) approach.

That is, in a first step, we run a series of time-series regressions similar to equations [4], [6], and [8] for a set of wine portfolios.[23] Building portfolios on the wine market is not trivial because of limited and infrequent trading, making it difficult to estimate the periodical return of specific portfolios accurately. We, therefore, consider two settings (to be able to assess the robustness of the results) and build eight "wine style" portfolios as well as fourteen "individual wine" portfolios (see section 5.4 for details). The first step gives us, for each portfolio, a set of loadings with respect to the various risk factors.

[23] We only consider models that do not include lagged risk factors because otherwise there would be too many regression coefficients to estimate on the basis of too few observations, thereby resulting in a non-robust analysis.

In a second step, we run a series of cross-sectional regressions. That is, for each period, we regress the excess return of the various wine portfolios on their risk factor loadings (estimated in the time-series regressions of step 1). For the CAPM (equation [4]), the liquidity-augmented CAPM (equation [6]), and for the liquidity and FX risk-augmented CAPM (equation [8]), the cross-sectional regressions take, respectively, the following forms:

$$R_{w,t} - r_{f,t} = a + b_{MKT,t}\beta_w + e_t \quad [10]$$

$$R_{w,t} - r_{f,t} = a + b_{MKT,t}\beta_w + b_{LIQ,t}\lambda_w + e_t \quad [11]$$

$$R_{w,t} - r_{f,t} = a + b_{MKT,t}\beta_w + b_{LIQ,t}\lambda_w + b_{RX,t}\gamma_w + b_{HML,t}\theta_w + e_t \quad [12]$$

The coefficients attached to the risk factor loadings capture the risk premia. They are averaged to determine whether a premium rewards an exposure of fine wines to a particular risk factor. To determine if a risk premium is significant, one further has to compute its standard error and compute a test statistics.

5 Results

5.1 Index estimation and evolution

Table 6 presents the results of the estimation of equation [2]. We consider three different specifications based on the variables presented in Table 5. All specifications achieve high R^2, ranging from 0.75 for the first specification to 0.84 for the third one.

The coefficients attached to each château are very stable from one specification to another, thereby supporting our results' robustness. In general, wines from the same appellation trade at similar prices. Among the fourteen wines from our sample, Pavie and Angélus (used as a reference in the regressions) are the least expensive. This price difference is due to the fact that these two estates were only very recently upgraded to First Growth A status (in 2012). Mission Haut-Brion tends to be slightly more expensive, followed by a wine group displaying similar pricing. Yquem and Margaux trade at prices close to those of Mouton-Rothschild, while the wines from all other estates command higher prices. The two historical First Growth A wines from Saint-Emilion (Ausone and Cheval Blanc), and Latour from Pauillac, are on average 50% pricier than Angélus. Lafite Rothschild trades at a premium of more than 140% compared with Angélus and is by far the most expensive wine from the Médoc and Graves regions. Finally, at the very high-end of the price spectrum are the two most exclusive wines from Pomerol - Pétrus and Le Pin - that cost approximately six to seven times more than Angélus.

Table 6 also demonstrates that quality is an essential determinant of wine prices. The relation between Parker scores and wine prices is not so much linear (little economic significance) than highly convex, indicating that wines with scores close to 100 points sell for extremely high prices. The coefficients attached to the auction house and location dummies show that a wine sold by Acker Merrall & Condit or Sotheby's in Hong Kong is likely to achieve much higher prices than the same wine offered by Morrell in the United States. Since 2008 and the abolishment of taxes on wines, Hong Kong has emerged as a new hub for wine trading. This has led to a dramatic increase in interest and trading activity in this part of the world. This increased activity seems to have affected wine prices. The Hong Kong coefficient indicates that prices are, on average, 15% to 20% higher there than elsewhere in the world. This is in line with prior evidence by Masset et al. (2016). The quantity of the same wine offered at the same auction has a slightly negative impact on the hammer price. In general, each additional bottle leads to a price decline of approximately 0.4% to 0.7%. Finally, a premium is attached to wines sold in their OWC.

< Insert Table 6 here >

Specification 1, which is the most parsimonious, illustrates that the relationship between age and price is, on average, positive. Specification 2 looks in more depth at the interaction between age and overall vintage quality. The aging process's impact is especially strong for outstanding vintages, which see their prices increasing at a steady rate of around 3.0% per year. The linear relation is weaker for vintages deemed less than outstanding at levels between 0.5% and 1.5%. This difference can be justified by outstanding vintages reaching their peak at a much older age than other vintages. Our results are in line with those from Dimson et al. (2015) and support the concept that a wine's aging potential strongly depends on vintage quality. Specification 3 investigates in greater detail the relationship between vintage and price. The vintage coefficients are displayed in Figure 2. By far, the most expensive vintage is 1945, which is followed by other great vintages, such as 1947, 1949, 1959, and 1961. Apart from a few exceptions (such as 1982 and, to a lesser extent, 1989, 1990, and 2000), recent vintages tend to be much cheaper than the legendary years.

< Insert Figure 2 here >

In Figure 3, we contrast the general wine index's evolution and various wine sub-indices. These indices are constructed based on subsamples that contain only selected wines: the first two indices focus respectively on old (more than twenty years) and young wines (twenty or fewer years); the following two indices consider high-quality (95 or more Parker points) or low-quality wines (less than 95 Parker points); and finally the remaining two indices contain wines from the left (Médoc and Graves) and the right (Saint-Emilion and Pomerol) bank of the Gironde. Over the entire sample period, the different sub-indices evolve similarly. However, some nuances exist, which may be due to a clientele effect. Some wines will find a global clientele, while others are more demanded in a specific region. This could impact their exposure to currency risk. Some wines may be relatively more liquid than others or traded more by investors and less by collectors. In this case, market and liquidity exposure may be of more importance.

The distinction of these sub-indices allows us to better understand the segmentation of the market and analyze whether some wine characteristics may influence prices and liquidity. Panel A looks at the wine age. We distinguish wines that are older than 20 years, which should thus start to be enjoyable, from those younger than twenty years. The older the wine, the rarer they become as more and more bottles are drunk. Consequently, they should appear less often at auctions. Overall, the evolution for both sub-indices and the general wine index is similar, but some nuances remain. This translates into an evolving price gap between young and old wines. Until 2006, the two sub-indices have performed equally well. Then, during increasing wine prices between 2006 and 2008, younger wines have delivered higher returns. The Global Financial Crisis (GFC) led to both a decline in the general wine index and in the performance of younger wines as compared to their older counterparts. After GFC, fine wines and, in particular, young fine wines rebounded very strongly. Finally, over the period 2012-2014, wine prices corrected and, again, young wines were the most affected. This contrasted dynamics suggests that young wines are more sensitive to wine market conditions than older wines. Moreover, a comparison between this panel and Figure 1 also suggests that the returns to young wines are affected by the evolution of the wine market's liquidity. All in one, this discussion reflects the diverging liquidity and customer base for young (wine investors sensitive to market movements and liquidity) and old wines (collectors buying for a more extended time period).

< Insert Figure 3 here >

Panel B distinguishes wines according to quality by separating wines into those having obtained more or less than 95 Robert Parker points. The evolution through time is, once again, not uniform. Between 2004 and 2008, the premium paid for quality wines widened and dropped thereafter. From a liquidity perspective, better-rated wines may be more demanded by market participants and thus turn up more often at auctions. Finally, Panel C distinguishes between production zones. The left bank is composed of producers with larger productions than on the right bank. Therefore, these wines should appear more often at auctions and be more liquid. Wines from the left bank outperformed their right bank counterparts by close to 50% from 2004 to 2009. Then, this outperformance progressively disappeared. This very dynamics can be attributed to both the Lafite Rothschild bubble (which burst in 2011) and the financialization of the wine market (epitomized by the arrival of investors and wine funds), which favored the more liquid wines from the left bank.

Figure 4 contrasts the general wine index's evolution, the market index (S&P500), and the different factors used. Wine prices have rapidly increased between 2005 and 2008 and then again between 2009 and 2011. These two periods of increase are associated with two combining elements: the advent of a great vintage (respectively, the 2005 vintage released in early 2006 and the 2009 vintage in 2010) combined with a bull stock market. In contrast, in 2008 and then again in 2011–2012, prices decreased substantially. The first correction, in 2008, parallels the financial crisis but was less severe than the decline in the stock markets. The second correction, in 2011, followed the bear market initiated by the Eurozone crisis and the release of the overpriced 2010 vintage.

Turning to the risk factors, the market appears to evolve similarly until the wine market correction in 2011. Since then, the stock market has increased while the wine market has remained relatively stable. Furthermore, the general wine index's evolution displays some similarities with the LIQ liquidity, RX, and HML_{FX} currency factors, indicating that the performance on the wine market may be related to liquidity and currency risk factors.

< Insert Figure 4 here >

Table 7 contains descriptive statistics for the general wine index, the equity market, and the different factors used in the empirical analysis (Panel A). This is complemented by statistics on the various wine sub-indices (Panel B). During 2003–2014, an index consisting of all First Growths from all vintages achieved an average return of approximately 11% per year. The sub-indices all perform similarly to the general wine market. However, younger, better-rated wines show slightly higher returns. Overall, all fine wines outperformed stocks but were also much more volatile. The returns on all fine wine indices exhibit a positive skewness and a positive excess kurtosis. Returns on equity indices also display a positive excess kurtosis but are negatively skewed. This pattern suggests that fine wines often experience large positive returns, while stocks are more prone to experience large negative returns. In line with McManus, Sharma, and Tezel (2013), wine indices display a substantial degree of negative autocorrelation, suggesting that they tend to overreact and subsequently correct. Fine wines' emotional nature and the fact that they do not deliver cash flows to their holders make them very prone to human biases, such as overreaction or speculative bubbles.[24]

< Insert Table 7 here >

5.2 Exposure of fine wines to systematic risk factors

Table 8 reports the results of the estimation of regression models [4] to [9]. We focus on the analysis of the general wine index estimated based on specification 3. We adopt a U.S. investor's perspective and therefore consider prices denominated in USD and use the S&P500 as a reference index for market returns in all regressions.[25] The upper panel uses data sampled monthly, and the lower panel uses quarterly data. When estimating models [5], [7], and [9], we use enough lagged factor returns to account for up to one complete quarter of delay in the wine market's reaction compared with the different factors used. We use up to three lags for monthly data to calculate wine's total exposure to market risk. For quarterly data, we use only one lag. This choice is supported by the Akaike and Schwarz information criteria, indicating that including more lags in the regressions is unnecessary. We further include an autoregressive term ϱ in each specification to account for the negative auto-correlation present on the wine market. This is consistent with the evidence presented above and past evidence on price reversals on the wine market (McManus et al., 2013). It allows us to explicitly take into account this form of autocorrelation that affects all wine indices.

[24] See Jovanovic (2013) for a detailed analysis of this phenomenon in the context of fine wine.
[25] We obtain similar results when using the MSCI World instead of the S&P 500.

< Insert Table 8 here >

Our results in columns 1 to 4 demonstrate that the conventional beta is positive and significant. When monthly data and only contemporaneous market returns are used, the beta becomes close to 0.30, which is considered relatively low. However, if the sampling frequency is lowered or lagged market returns are added to the CAPM regression, the R^2 of the regressions and the beta increase substantially. When quarterly data are used, the beta reaches values of approximately 0.50 to 0.60. A bootstrap simulation further demonstrates that the difference between the beta obtained from quarterly and monthly data is statistically significant. To run this simulation, we use 100,000 random shuffles of the initial wine and factor returns. The aim is to break the temporal dynamics of returns. For this approach to be appropriate, three conditions must be met: the relationship must be stable (Chow test), the returns must be stationary, and the volatility needs to be constant. If the latter is not the case, the returns must be adjusted, such as not to alter the volatility dynamics initially present in the data. The first two conditions are satisfied in our data. However, the third condition is not. The fact that volatility fluctuates has been documented in the literature, including that on wine (Ben Ameur & Le Fur, 2020). A GARCH type process is therefore needed. To further account for the asymmetric nature of the relationship between returns and volatility, we use an EGARCH process. This allows for the negative skewness of equity and the positive skewness of wine to be taken into account. Note that even with monthly data, when lagged market returns are used, the total beta increases and consistently exceeds 0.50. In general, the beta at lag 1 is the largest and most significant. Adding another lag to the regression is not useful because the corresponding betas, although generally positive, are not significant and lower. Contrary to most recent studies on wine as an investment, none of the alphas turns out to be significantly positive because of three elements: our indices are more precise and more reactive than those used in the literature to date; we use a methodology that explicitly accounts for the potential consequences of illiquidity; our sample period is longer and more recent.

Columns 5 to 8 of Table 8 are structured similarly to the first four columns. They report the results for models [6] and [7], thereby enabling an observation of the impact of liquidity on the initial results. The MKT betas are only moderately affected by the liquidity risk factor's inclusion into the regression and remain relatively stable compared with those obtained using models [4] and [5]. Table 8 further shows that the returns to fine wines are also affected by their exposure to liquidity risk. For monthly data, the contemporaneous exposure of fine wines to liquidity risk, captured via λ in model [6], turns out to be distinctly larger than the exposure to market risk, measured by β. When lagged realizations of market and liquidity risks are added to the regression (model [7]), one observes that the wine market tends to react with a delay to changes in stock market conditions (because $\beta_{lag\ 1}$ is slightly larger than the contemporaneous beta). However, it adapts more rapidly to liquidity risk changes (because the contemporaneous λ is much larger and more significant than λ_{lag1}). The results are slightly different when quarterly data are considered. In this case, β is significant, while λ lacks significance and decreases in magnitude compared to monthly data.

Columns 9 to 12 augment the previous model with the two currency factors and report the results for models [8] and [9]. The MKT betas are heavily affected by the inclusion of the currency risk factors into the regression and turn negative and insignificant compared with those obtained using models [4] and [5]. The lower significance of market risk is not surprising given the wine market's exposure to exchange rates and, in particular, the evolution of the USD (captured through RX) and to world risk (proxied by HML). The results further show that the returns to fine wines remain affected by their exposure to contemporaneous liquidity risk but at a lower level. In both cases, lagged exposure does not have a significant effect. However, currency exposure of wine is highly important with a substantial and significant contemporaneous and one-period lagged coefficient for the RX factor. The contemporaneous exposure of fine wines to currency risk is distinctly larger than the exposure to market risk and liquidity risk for monthly data. The results are slightly different when quarterly data are considered. In this case, β and λ lack significance, but currency risk remains highly significant and displays a magnitude similar to monthly data.

In summary, the results presented so far illustrate that the lack of liquidity and the exposure to currency risk of the wine market impact its adjustment to changes in financial conditions and is perceived as a source of risk by investors. In the following section, we study different wine market sub-indices to deepen our understanding of this relationship. We then conduct a Fama-MacBeth approach to examine whether a risk premium exists for these different risk exposures on the wine market.

5.3 Exposure of fine wine sub-indices to systematic risk factors

Hereafter, we use the indices presented in Figure 3 to examine the six sub-indices' exposure along the age, quality, and production area sub-dimensions to market, liquidity, and currency risks. This subsample analysis's primary objective is to examine how the liquidity and the degree of financialization and globalization of particular wines affect their returns and exposure to risk factors. As exhibited in Figure 3 the various sub-indices do not always evolve the same way. This is mainly due to their different characteristics, which attract different types of buyers. For instance, older wines tend to attract more amateurs and collectors, while investors generally favor younger wines. Thus, the inclusion into the analysis of two separate indices for young and old wines enables us to examine whether a clientele effect exists and affects the risk and return features of specific categories of fine wines. This subsample analysis also allows us to determine whether particular types of wines offer better performance than others.

< Insert Table 9 here >

The results for specific wine categories are economically significant and robust compared to those obtained in the previous subsection. However, due to the low number of observations, statistical significance is lacking at times. All types of fine wines seem to be exposed to some degree of risk. Panel A (monthly data) indicates that especially wines from the Gironde's left bank display a lower exposure to market risk than the other wines. For the other sub-indices total beta coefficients remain rather similar. Total λ further shows that older and lower quality wines are more exposed to liquidity risk. This result is not a surprise given that those wines are less liquid than their counterparts. Indeed, investors and fund managers look for investing in wines that can easily be found on the market to reduce search and transaction costs. These wines come from young vintages (still available from most wine merchants) and are of the highest quality (search for perfection). Finally, we find significant currency exposure on the RX but not on the HML_{FX} factor on a contemporaneous and lagged basis for all wine sub-indices. Here it is mainly those wines best known by a professional clientele and all clients on a global scale (young wines of the left bank with a low-quality rating) that display the most economic significance.

For data sampled quarterly (panel B), findings remain similar to those on a monthly basis. β coefficients increase and turn significant for right bank wines only. Liquidity risk remains positive but at a lower magnitude. Finally, currency exposure remains significant and economically important at a contemporaneous level. Overall, all wine categories are significantly exposed to currency risk and somewhat sensitive to market and liquidity risks, albeit not statistically significantly. None of the wine indices generate a significantly positive alpha.

Table 10 reports results on the liquidity and currency-augmented CAPM for the 14 individual châteaux considered in our sample. Overall, the results remain robust and in line with those of Tables 8 and 9. Contemporaneous market exposure remains low, centered around zero and in a range of -0.25 to 0.21. Some wines are affected by lags in exposure, and total beta estimates generally tend to increase. Half of the wines also display an economically and statistically significant liquidity factor loading at the contemporaneous level but not for lags. Finally, another half of wines are exposed to currency risk at the contemporaneous, one-period lag, or total level. All results appear to hold using quarterly data.

< Insert Table 10 here >

5.4 Portfolio and Fama-MacBeth analysis

To assess whether wine investors may effectively expect to receive a risk premium for the risks they take when investing in wine we run Fama-MacBeth cross-sectional regressions.[26] We use quarterly data to obtain the best possible trade-off between the number of observations and variables in the estimation of the indices and the Fama-MacBeth regressions. It also allows us to work with unlagged risk factors. The first column of Table 11 includes eight wine style portfolios constructed based on the area of production (left and right bank), scores (above 95 points and below or equal to 95 points), age (less than 20 years old and 20 years old or more). Column 2 uses 14 individual wine portfolios built based on the wine producers (14 châteaux). Due to the presence of negative auto-correlation in the data, we use, in all cases, autoregressive corrected returns in the form of $R_t = R_t - \rho R_{t-1}$. ρ corresponds to the coefficient estimated in the time-series regressions in the first pass.

Panel A examines the classic CAPM and finds coherent results for both specifications with a market risk premium of around 10% per year. In Panel B, we show that liquidity yields a positive and important risk premium for the individual wine portfolios but a negative risk premium for the eight wine-style portfolios. It also reduces market risk premia in both cases. This may be due to the relative complexity of obtaining homogenous portfolios with distinct wine profiles while maintaining an appropriate number of observations to estimate robust regressions. Finally, in Panel C, both currency factors appear to yield substantial risk premia. At the same time, other coefficients remain close to those of Panel B. Overall, the different risk premia appear to be priced in wine returns. Unfortunately, results remain statistically insignificant due to the small sample size.

[26] In unreported results we also use different clustered standard errors in pooled regressions. We run regressions with (i) period, (ii) portfolio and (iii) period and portfolio clusters. Following Petersen (2009), we also run regressions with period fixed effects or period fixed effects and portfolio clustered standard errors. In all cases, findings show little significance.

< Insert Table 11 here >

Our results appear relatively coherent once we compare the estimated risk premia with the effectively realized average returns of the factors. Both display similar magnitudes. When comparing the wine style and individual portfolios, results at times diverge. This may be explained by the age of the wines, which are an essential characteristic. However, it is complex to build portfolios on this axis as wines may change from one wine style portfolio to another due to their aging as time passes. This can potentially affect the quality of the estimation in a hedonic model.

5.5 Robustness tests

As discussed in the literature review, assessing a wine investment's performance crucially depends on the research design on which one settles. To ensure that our results are reliable and not driven by specific choices regarding the research design and the methodology used, we conduct various robustness tests.[27]

1. **Index construction methodology:** We re-estimate all of our wine indices using the RSR approach instead of the HR approach. The RSR is constructed in a way that mechanically controls for all heterogeneity sources among different wines but uses only wines that have been traded at least twice. As such, the resulting wine index may have (slightly) different statistical properties from the one obtained using the HR approach.

   Comments: the results do not change significantly when indices computed using the RSR approach are used.

2. **Benchmark indices:** Given the complex and international nature of the wine market, in addition to the S&P 500 indices, we re-estimate the beta using several other benchmark indices. In particular, we consider the CAC 40 (because Bordeaux First Growths are produced in France, it seems logical to use a French stock market index), the FTSE 100 (most wine investment companies and funds are based in London), the Hang Seng Index (during the last decade, Hong Kong has rapidly emerged as one of the most important marketplaces for Bordeaux wines), and the MSCI World (wines can be sold throughout the world).

   Comments: Whichever reference stock market index is considered, fine wines maintain a positive market risk exposure. In general, however, the beta is lower when the CAC 40 or the FTSE 100 is used instead of the S&P 500.

[27] More detailed results are available from authors on request.

3. **Asset pricing model and risk factors:** So far, we have considered only three systematic risk sources, namely market, liquidity, and currency risk. However, other risk factors may affect wine returns. Therefore, we complement our analysis by using three additional factors: the SMB and the HML factors of Fama and French (1993) and the MOM of Carhart (1997). These factors have already been found to explain a substantial part of stock returns. Fine wines, such as other collectibles, are often considered alternative assets. As such, their price dynamics and returns are likely to be affected by risk factors that differ from those affecting stock and bond prices. Therefore, we run an additional robustness test using five risk factors that have been found to explain a substantial part of the returns to alternative investments (Fung & Hsieh, 2001, 2002, 2004).

   Comments: Apart from the conventional beta, only the global SMB factor turns out to be significant in the regressions at the cost of the liquidity factor. This finding suggests that the SMB factor which has been proposed as a proxy for liquidity on stock markets has a somewhat similar effect to the liquidity factor. All other factors are insignificant and thus irrelevant in explaining the returns to an investment in fine wine. One reason may be due to the fact that the HML and MOM factors have been designed to be applied on stocks, while the purpose of the Fung and Hsieh factors is first and foremost to replicate various types of hedge fund investment strategies. This result further reinforces the conjecture that liquidity risk is likely to affect many asset classes and not just the most liquid ones (such as stocks and bonds).

6 Conclusion

In this paper, we estimate several indices that track the performance of various categories of fine wines from 2003 to 2014. These indices have achieved substantial returns of 10 to 12% per year. From this perspective, fine wines have fared better than most other asset classes during this period. However, note that fine wines have also been quite volatile and have experienced a substantial price correction since 2011. Moreover, fine wines appear to be significantly exposed to market, liquidity, and currency risks. Fine wines tend to react with a delay of approximately one to three months to changes in market conditions. This delay can be explained by the lack of liquidity in the wine market that impedes more rapid adjustments. Wine also appears exposed to liquidity risk. Currency risk also has a substantial effect on wine returns. Put together, these results indicate that when properly accounting for the inherent characteristics of the fine wine market, an investment in it turns out to be riskier than usually believed. Even worse, such investments do not appear to generate significant abnormal returns. The relatively high R^2 (compared with previous studies) obtained in most test specifications and various robustness tests further strengthen the evidence presented in this paper.

From an academic viewpoint, the observation that a substantial part of the returns are driven by common risk factors and, in particular, by liquidity and currency risks stands in apparent contradiction to previous evidence (see, e.g., Sanning et al. (2008) and Masset and Weisskopf (2018a)) on the performance of such investments. Nevertheless, this observation is in agreement with the literature on currency risk and the premium associated with it. In an increasingly globalized world in which investors can invest in multiple asset classes worldwide, currency risk becomes omnipresent for any type of investment. The interest in analyzing an asset such as wine, or any other collectible, is its easy tradability and transportability, making it a real global asset with few restrictions on potential trading places. In this case, the effect of exchange rates is even more pronounced and of interest to investors. This should be further studied for other collectibles such as classic cars or art that have also strongly gained in popularity over the past years. Especially since the COVID-19 pandemic and auction houses turning progressively to online solutions, the international exposure of collectibles has further increased.

Our finding on the wine market's liquidity is also in agreement with the literature on alternative investments. Assets such as private equity, real estate, and hedge funds tend to be relatively illiquid and can become especially difficult to sell when markets tumble. Thus, investors generally need to be compensated for bearing this type of risk. Furthermore, the fact that a liquidity factor estimated based on stock returns can explain the returns on an exotic asset such as wine suggests that illiquidity is a common, cross-asset source of risk. Hence, this paper contributes to the literature on alternative investments and wine as an asset class and provides additional evidence regarding the nature of commonly encountered risks. It also paves the way for further research on the dynamics of this cross-asset source of risk and how the wine market interacts in a portfolio that is not only invested in traditional assets but also in newly popular and illiquid asset classes such as private equity or real estate. This has not been studied in depth thus far.

From a practical viewpoint, the results presented in this paper are certainly disappointing for wine investors but do not invalidate such investments. They simply demonstrate that fine wines and, more particularly, simple buy-and-hold strategies involving fine wines do not deliver positive abnormal returns. This finding suggests that such investments are riskier than usually thought and require a genuine understanding of the wine market. Nevertheless, wine investments can still be attractive in terms of diversification and, more importantly, may allow investors to obtain important exposure to particular sources of risk. Notably, such exposure can be particularly relevant for investors with a long-term investment horizon. Moreover, we show that different types of wines can display rather different price dynamics. For instance, investing in old vintages may enable better diversification because those wines have a lower correlation with other asset categories. As the First Growths constitute the most visible and traded part of the wine market it may be of interest to further analyze the evolution and beneficial properties of wines from other wine regions, which may be less liquid but also less globalized and thus less prone to currency fluctuations. All in one, our results suggest that it is naïve to expect abnormal returns just by investing blindly in a static basket of First Growths from the most recent and adulated vintages. To develop a successful investment strategy, a thorough analysis is crucial to identifying genuine opportunities. This observation opens the door for dynamic and creative investment strategies with dedicated risk exposure.

7 List of references

Acharya, V. V., & Pedersen, L. H. (2005). Asset Pricing with Liquidity Risk. *Journal of Financial Economics, 77*(2), 375-410.

Adler, M., & Dumas, B. (1984). Exposure to Currency Risk: Definition and Measurement. *Financial management*, 41-50.

Amihud, Y., Mendelson, H., & Pedersen, L. H. (2006). *Liquidity and Asset Prices*: Now Publishers Inc.

Anderson, K., & Wittwer, G. (2018). Cumulative Effects of Brexit and Other Uk and Eu-27 Bilateral Free-Trade Agreements on the World's Wine Markets. *The World Economy, 41*(11), 2883-2894.

Ashenfelter, O. (2008). Predicting the Quality and Prices of Bordeaux Wine. *The Economic Journal, 118*(529), F174-F184.

Aytaç, B., Coqueret, G., & Mandou, C. (2018). Herding Behavior among Wine Investors. *Economic Modelling, 68*, 318-328.

Aytaç, B., Hoang, T.-H.-V., & Mandou, C. (2016). Wine: To Drink or Invest In? A Study of Wine as an Investment Asset in French Portfolios. *Research in International Business and Finance, 36*, 591-614.

Baumol, W. J. (1986). Unnatural Value: Or Art Investment as Floating Crap Game. *The American Economic Review, 76*(2), 10-14.

Ben Ameur, H., & Le Fur, E. (2020). Volatility Transmission to the Fine Wine Market. *Economic Modelling, 85*, 307-316.

Bouri, E., Gupta, R., Wong, W.-K., & Zhu, Z. (2018). Is Wine a Good Choice for Investment? *Pacific-Basin Finance Journal, 51*, 171-183.

Bouri, E. I., & Roubaud, D. (2016). Fine Wines and Stocks from the Perspective of Uk Investors: Hedge or Safe Haven? *Journal of Wine Economics, 11*(2), 233-248. doi:10.1017/jwe.2015.10

Burton, B. J., & Jacobsen, J. P. (2001). The Rate of Return on Investment in Wine. *Economic Inquiry, 39*(3), 337-350.

Byron, R. P., & Ashenfelter, O. (1995). Predicting the Quality of an Unborn Grange. *Economic Record, 71*(1), 40-53.

Campbell, J. Y., Giglio, S., & Pathak, P. (2011). Forced Sales and House Prices. *American Economic Review, 101*(5), 2108-2131.

Cardebat, J.-M., Faye, B., Le Fur, E., & Storchmann, K. (2017). The Law of One Price? Price Dispersion on the Auction Market for Fine Wine. *Journal of Wine Economics, 12*(3), 302.

Cardebat, J.-M., & Figuet, J.-M. (2019). The Impact of Exchange Rates on French Wine Exports. *Journal of Wine Economics, 14*(1), 71-89.

Cardebat, J.-M., Figuet, J.-M., & Paroissien, E. (2014). Expert Opinion and Bordeaux Wine Prices: An Attempt to Correct Biases in Subjective Judgments. *Journal of Wine Economics, 9*(3), 282.

Carhart, M. M. (1997). On Persistence in Mutual Fund Performance. *The Journal of finance, 52*(1), 57-82.

Chanel, O., Gérard-Varet, L.-A., & Ginsburgh, V. (1996). The Relevance of Hedonic Price Indices. *Journal of Cultural Economics, 20*(1), 1-24.

Combris, P., Lecocq, S., & Visser, M. (1997). Estimation of a Hedonic Price Equation for Bordeaux Wine: Does Quality Matter? *The Economic Journal, 107*(441), 390-402.

Combris, P., Lecocq, S., & Visser, M. (2000). Estimation of a Hedonic Price Equation for Burgundy Wine. *Applied Economics, 32*(8), 961-967.

De Santis, G., & Gerard, B. (1998). How Big Is the Premium for Currency Risk? *Journal of Financial Economics, 49*(3), 375-412.

Di Vittorio, A., & Ginsburgh, V. (1996). Pricing Red Wines of Medoc Vintages from 1949 to 1989 at Christie's Auctions. *Journal de la Société Statistique de Paris, 137*(1), 19-49.

Dimson, E. (1979). Risk Measurement When Shares Are Subject to Infrequent Trading. *Journal of Financial Economics, 7*(2), 197-226.
Dimson, E., Rousseau, P. L., & Spaenjers, C. (2015). The Price of Wine. *Journal of Financial Economics, 118*(2), 431-449.
Dimson, E., & Spaenjers, C. (2011). Ex Post: The Investment Performance of Collectible Stamps. *Journal of Financial Economics, 100*(2), 443-458.
Erdős, P., & Ormos, M. (2013). Components of Investment Grade Wine Prices. *Journal of wine research, 24*(3), 227-247.
Fama, E. F., & French, K. R. (1993). Common Risk Factors in the Returns on Stocks and Bonds. *Journal of Financial Economics, 33*, 3-56.
Fama, E. F., & MacBeth, J. D. (1973). Risk, Return, and Equilibrium: Empirical Tests. *Journal of Political Economy, 81*(3), 607-636.
Faye, B., Le Fur, E., & Prat, S. (2015). Dynamics of Fine Wine and Asset Prices: Evidence from Short-and Long-Run Co-Movements. *Applied Economics, 47*(29), 3059-3077.
Fernandez-Perez, A., Frijns, B., Tourani-Rad, A., & Weisskopf, J.-P. (2019). Behavioural Heterogeneity in Wine Investments. *Applied Economics, 51*(30), 3236-3255.
Fogarty, J. (2006). The Return to Australian Fine Wine. *European Review of Agricultural Economics, 33*(4), 542-561.
Fogarty, J. (2010). Wine Investment and Portfolio Diversification Gains. *Journal of Wine Economics, 5*(1), 119-131.
Fogarty, J., & Jones, C. (2011). Return to Wine: A Comparison of the Hedonic, Repeat Sales and Hybrid Approaches. *Australian Economic Papers, 50*(4), 147-156.
Fogarty, J., & Sadler, R. (2014). To Save or Savor: A Review of Approaches for Measuring Wine as an Investment. *Journal of Wine Economics, 9*(3), 225-248.
Fung, W., & Hsieh, D. A. (2001). The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers. *The Review of Financial Studies, 14*(2), 313-341.
Fung, W., & Hsieh, D. A. (2002). Asset-Based Style Factors for Hedge Funds. *Financial Analysts Journal, 58*(5), 16-27.
Fung, W., & Hsieh, D. A. (2004). Hedge Fund Benchmarks: A Risk-Based Approach. *Financial Analysts Journal, 60*(5), 65-80.
Glück, M., Hübel, B., & Scholz, H. (2020). Currency Conversion of Fama–French Factors: How and Why. *The Journal of Portfolio Management, 47*(2), 157-175.
Introvigne, S., Bacchiocchi, E., & Vandone, D. (2017). A Cointegration Analysis of Wine Stock Indices. *Working Paper.*
Jaeger, E. (1981). To Save or Savor: The Rate of Return to Storing Wine. *Journal of Political Economy, 89*(3), 584-592.
Jensen, M. C. (1968). The Performance of Mutual Funds in the Period 1945-1964. *The Journal of finance, 23*(2), 389-416.
Jiao, L. (2017). Macroeconomic Determinants of Wine Prices. *International Journal of Wine Business Research.*
Jones, G. V., & Storchmann, K. H. (2001). Wine Market Prices and Investment under Uncertainty: An Econometric Model for Bordeaux Crus Classés. *Agricultural Economics, 26*(2), 115-133.
Jovanovic, B. (2013). Bubbles in Prices of Exhaustible Resources. *International Economic Review, 54*(1), 1-34.
Jurevičienė, D., & Jakavonytė, A. (2015). Alternative Investments: Valuation of Wine as a Means for Portfolio Diversification. *Business: Theory and Practice, 16*(1), 84-93.
Kourtis, A., Markellos, R. N., & Psychoyios, D. (2012). Wine Price Risk Management: International Diversification and Derivative Instruments. *International Review of Financial Analysis, 22*, 30-37.

Krasker, W. S. (1979). The Rate of Return to Storing Wines. *Journal of Political Economy, 87*(6), 1363-1367.
Landon, S., & Smith, C. E. (1997). The Use of Quality and Reputation Indicators by Consumers: The Case of Bordeaux Wine. *Journal of Consumer Policy, 20*(3), 289-323.
Le Fur, E., Ben Ameur, H., Braune, E., & Faye, B. (2016). Financial Market Contagion and Fine Wines: The Evidence of the Adcc Garch Model. *International journal of entrepreneurship and small business, 29*(4), 583-601. doi:10.1504/ijesb.2016.079967
Le Fur, E., Ben Ameur, H., & Faye, B. (2016). Time-Varying Risk Premiums in the Framework of Wine Investment. *Journal of Wine Economics, 11*(3), 355-378. doi:10.1017/jwe.2016.15
Le Fur, E., & Outreville, J.-F. (2019). Fine Wine Returns: A Review of the Literature. *Journal of Asset Management, 20*(3), 196-214.
Lintner, J. (1965). Security Prices, Risk, and Maximal Gains from Diversification. *The Journal of finance, 20*(4), 587-615.
Liu, W. (2006). A Liquidity-Augmented Capital Asset Pricing Model. *Journal of Financial Economics, 82*(3), 631-671.
Lucey, B. M., & Devine, L. (2015). Was Wine a Premier Cru Investment? *Research in International Business and Finance, 34*, 33-51.
Lustig, H., Roussanov, N., & Verdelhan, A. (2011). Common Risk Factors in Currency Markets. *The Review of Financial Studies, 24*(11), 3731-3777.
Malter, D. (2014). On the Causality and Cause of Returns to Organizational Status: Evidence from the Grands Crus Classés of the Médoc. *Administrative Science Quarterly, 59*(2), 271-300.
Masset, P., & Henderson, C. (2010). Wine as an Alternative Asset Class. *Journal of Wine Economics, 5*(1), 87-118.
Masset, P., & Weisskopf, J.-P. (2015). Wine Funds: An Alternative Turning Sour? *The Journal of Alternative Investments, 17*(4), 6-20.
Masset, P., & Weisskopf, J.-P. (2016). A Study of the Performance of Fine Wine on the Swiss Market. *International journal of entrepreneurship and small business, 29*(4), 566-582.
Masset, P., & Weisskopf, J.-P. (2018a). Raise Your Glass: Wine Investment and the Financial Crisis. In O. Ashenfelter, O. Gergaud, K. Storchmann, & W. Ziemba (Eds.), *Handbook of the Economics of Wine* (Vol. 2, pp. 271-296). Singapore: World Scientific.
Masset, P., & Weisskopf, J.-P. (2018b). Wine Indices in Practice: Nicely Labeled but Slightly Corked. *Economic Modelling, 68*, 555-569.
Masset, P., Weisskopf, J.-P., & Cossutta, M. (2015). Wine Tasters, Ratings, and En Primeur Prices. *Journal of Wine Economics, 10*(1), 75.
Masset, P., Weisskopf, J.-P., & Fauchery, C. (2020). Last Frontier Investments: The Case of Alpine Wines. *Journal of Wine Economics, 15*(2), 181-206.
Masset, P., Weisskopf, J.-P., Faye, B., & Le Fur, E. (2016). Red Obsession: The Ascent of Fine Wine in China. *Emerging markets review, 29*, 200-225.
McManus, G., Sharma, R., & Tezel, A. (2013). Reversals in Wine Auction Prices. *Journal of Wine Economics, 8*(2), 189.
Mei, J., & Moses, M. (2002). Art as an Investment and the Underperformance of Masterpieces. *American Economic Review, 92*(5), 1656-1668.
Mossin, J. (1966). Equilibrium in a Capital Asset Market. *Econometrica: Journal of the econometric society*, 768-783.
Oczkowski, E., & Doucouliagos, H. (2015). Wine Prices and Quality Ratings: A Meta-Regression Analysis. *American Journal of Agricultural Economics, 97*(1), 103-121.
Onur, I., Bruwer, J., & Lockshin, L. (2020). Reducing Information Asymmetry in the Auctioning of Non-Perishable Experience Goods: The Case of Online Wine Auctions. *Journal of Retailing and Consumer Services, 54*, 102060.

Pástor, Ľ., & Stambaugh, R. F. (2003). Liquidity Risk and Expected Stock Returns. *Journal of Political Economy, 111*(3), 642-685.
Petersen, M. A. (2009). Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches. *Review of financial studies, 22*(1), 435-480.
Rosen, S. (1974). Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. *Journal of Political Economy, 82*(1), 34-55.
Sanning, L. W., Shaffer, S., & Sharratt, J. M. (2008). Bordeaux Wine as a Financial Investment. *Journal of Wine Economics, 3*(1), 51-71.
Schamel, G., & Anderson, K. (2003). Wine Quality and Varietal, Regional and Winery Reputations: Hedonic Prices for Australia and New Zealand. *Economic Record, 79*(246), 357-369.
Scholes, M., & Williams, J. (1977). Estimating Betas from Nonsynchronous Data. *Journal of Financial Economics, 5*(3), 309-327.
Sharpe, W. F. (1964). Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk. *The Journal of finance, 19*(3), 425-442.
Storchmann, K. (2012). Wine Economics. *Journal of Wine Economics, 7*(1), 1-33.

(Aytaç, Hoang, & Mandou, 2016; E. I. Bouri & Roubaud, 2016; Jurevičienė & Jakavonytė, 2015; Le Fur, Ben Ameur, Braune, & Faye, 2016; Le Fur, Ben Ameur, & Faye, 2016; Lucey & Devine, 2015; Masset & Weisskopf, 2016)

Table 1: Overview of the existing literature

Authors (year) *Source*	Data	Methodology used	Period	Performance		
				Returns	Volatility	Diversification
KRASKER (1979) *Journal of Political Economy*	Annual Heublein Wine Auction. 137 observations (red Bordeaux and California Cabernet Sauvignon; vintages before 1950 are excluded).	PR: dep = excess returns to wine; indep = constant + storage costs. The constant provides an estimate of the difference in return between wine and US T-bills.	1973 - 1977	Wines do not outperform US T-bills in terms of returns.	*Not investigated*	*Not investigated*
JAEGER (1981) *Journal of Political Economy*	Annual Heublein Wine Auction. 199 observations (red Bordeaux and California Cabernet Sauvignon; vintages before 1950 are excluded).	Same approach as Krasker (1979), except that the storage costs are not estimated (explicitly set to USD 0.449 per bottle and per year).	1969 - 1977	Wines do significantly outperform US T-bills in terms of returns.	*Not investigated*	*Not investigated*
BYRON and ASHENFELTER (1995) *Economic Record*	Langton's auctions. Penfold's Grange, vintages 1959 to 1987.	HR: indep = age + weather variables. The coefficient associated to the age variable provides an estimate of the expected real rate of TS: dep = return; indep = constant.	1991 - 1994	3.9% real rate of return (HR) (12-13% in nominal terms). 18% nominal rate of return (TS).	*Not investigated*	*Not investigated*
De VITTORIO and GINSBURGH (1996) *Journal de la Société Statistique de Paris*	Christie's wine auctions (London). 29,901 observations (red Bordeaux; vintages 1949-1988).	HR: indep = year of sale + age + other variables.	1980 - 1992	3.7% (expected real rate of return - ageing effect). 4.2% (average nominal rate of return over the period).	10.20%	*Not investigated*
BURTON and JACOBSEN (2001) *Economic Inquiry*	Edgerton (1986-1997) *Wine Price File.* 10,558 observations (red Bordeaux; vintage after 1960; bi-annual data).	RSR: estimation of several wine indices. Analysis of the returns of the various wine indices.	1986 - 1996	Average return of 7.9% for a diversified wine portfolio (13.9% for 1982 Bordeaux). Wines offer higher returns than bonds but lower than equities.	18.8% (diversified portfolio; 19% for 1982 Bordeaux). Wines are much more volatile than stocks and bonds.	*Not investigated*
JONES and STORCHMANN (2001) *Agricultural Economics*	Blättel and Stainless (auction data) 306 observations (21 Bordeaux wines; vintages 1980-1994).	PR (close in spirit to a HR): dep = price; indep = age + Parker points + other variables. Primary purpose is to forecast wine prices.	1996	Annual real rate of return of 1.2% to 9.6% (depending on the château).	*Not investigated*	*Not investigated*
FOGARTY (2006) *European Review of Agricultural Economics*	Langton's auctions. 14,102 observations (84 Australian wines; vintage before 1965 are excluded).	HR: indep = period of sale + quality-related variables.	1989 - 2000	Quarterly rate of return: 2.35%. Subindices defined on the basis of price offer different returns (3.17% for the most expensive,	Quarterly volatility: 4.42% (respectively 4.74% and 5.34% for the most and the least expensive	*Not investigated*
SANINNG et al. (2008) *Journal of Wine Economics*	The Chicago Wine Company (auction data). 13,662 observations (90 red wines; vintage 1893-1998).	Wine returns calculated from repeated transactions and for each wine separately. Performance analysed using the CAPM and the Fama-French Three Factor model.	1996 - 2003	Average excess return of 7.5% to 9.5% p.a. Abnormal returns (alpha) on average positive and significant.	Depending on the category of wine considered, the volatility varies between 21% and 27%.	Beta insignificant and close to 0 (and often slightly negative). Wine offers an important diversification potential.
FOGARTY (2010) *Journal of Wine Economics*	Langton's auctions. 12,180 observations (84 Australian wines).	RSR: estimation of a wine index for Australian wines. Tests to determine if adding wine to a portfolio improves its risk-return profile.	1990 - 2000	Average quarterly return of 2.05% versus 2.67% for Australian equities and 2.84% for Australian bonds.	Wines have a lower volatility (3.93%, quarterly basis) than Australian equities (5.80%) but higher than bonds (3.15%).	Wines are weakly correlated with equities (correlation of 0.14) and negatively with bonds (-0.11). They provide diversification gains.
MASSET and HENDERSON (2010) *Journal of Wine Economics*	The Chicago Wine Company (auction data). 77,014 observations (92 red Bordeaux; from 29 vintages).	Wine indices calculated from repeated transactions. Mean-variance and higher-moment portfolio analyses	1996 - 2007	Total cumulated return of the wine market index of 145% (220% for outstanding wines) versus 127% for the Dow Jones.	The general wine market index has a lower volatility than the Dow Jones (8.1% versus 15%).	Limited correlation between wines and other assets. Wine improves a portfolio's risk-return profile.

Table 1 (con't)

Authors (year) *Source*	Data	Methodology used	Period	Performance		
				Returns	Volatility	Diversification
KOURTIS et al. (2012) *International Review of Financial Analysis*	WinePrice (2005 to 2010) and Liv-ex. Monthly indices (wines from several countries).	Analysis of the diversification potential offered by wines from different countries. Proposition regarding the development of dedicated wine derivatives.	2001 - 2010	High returns, though dependent on the region considered. Average monthly return of 2% (Australian wines) to 18% (Bordeaux).	Volatility of 18% (Californian wines) to 28% (Bordeaux). Volatility generally higher than for equities.	Limited correlation of wine with equities (<0.3). Diversification potential offered by wines from different origins.
DIMSON et al. (2015) *Journal of Financial Economics (Forthcoming)*	Christie's London (auction data) and Berry Bros. & Rudd (retail prices) 36,271 observations (First growths from Bordeaux).	Value-weighted RSR to estimate a wine index. Analysis of the returns to wine investments (using a market models) and of their life-cycle price dynamics (within a HR framework).	1899 - 2012	Average real rate of return of 5.3% (4.1% after adjustments for insurance and storage costs) versus 5.2% for equities, 1.5% for bonds, 2.4% for art and 2.8% for stamps.	Wines are much more volatile than other asset classes (volatility of 26.9% on annual basis) including equities (21.6%), bonds (11.9%), art (13.2%) and stamps (13.5%).	Wines are significantly correlated with equities. Their total beta is between 0.57 and 0.73 (depending on the period considered).
DEVINE and LUCEY (2015) *Research in International Business and Finance*	The Chicago Wine Company (auction data) and data on wine funds. 69,903 observations (Bordeaux and Rhone wines) and returns on 5 funds.	Index calculations using the RSR approach. Analysis of performance, primarily on the basis of the Sharpe ratio.	1996 - 2007	Average return of 5.2% for a diversified wine portfolio (3.2% for Bordeaux and 5.5% for Rhone), versus 4.9% for the Dow Jones.	Volatility of 9.1% for a diversified wine portfolio (10.4% for Bordeaux and 8.9% for Rhone), versus 17.6% for the Dow Jones.	*Not investigated*
MASSET and WEISSKOPF (2015) *Journal of Alternative Investments*	Monthly closing values of 9 wine funds. Depending on the fund considered, 54 to 129 observations are available.	Analysis of fund managers' performance (including selectivity and market timing skills). Use of the CAPM, Fama-French three factors and Carhart four factors models.	2000 - 2013	Most funds beat the S&P 500 but not the S&P 500 Beverages and the bond indices. Abnormal returns are not significantly different from 0 for all funds but one.	All but two funds have a lower volatility than equity indices. They are however more volatile than the bond index.	Most funds have a positive and significant beta.
FAYE et al. (2015) *Applied Economics*	Auction prices Australia, Bordeaux, Burgundy, California, Italy, Portugal	Cointegration procedures, Granger non-causality test, ECM	2003 - 2012	*Not investigated*	*Not investigated*	There is a short-run causality between the wines themselves. Portfolio diversification strategies including wines are relevant.
JUREVICIENE and JAKAVONYTE (2015) *Business: Theory and Practice*	Liv-ex indices Bordeaux	Markowitz's investment portfolio theory	1993 - 2012			Wine relevance for portfolio diversification in post crises is proved.
AYTAC and MANDOU (2016) *Research in International Business and Finance*	Liv-ex indices Winedex indices French wines	Mean-variance portfolio optimization approach	2007 - 2014	The higher the proportion of wine, the higher the portfolio performance is. iDealwine indexes, particularly WineDex Bordeaux, are more profitable than Liv-ex ones.		
BOURI and ROUBAUD (2016) *Journal of Wine Economics*	Liv-ex indices Bordeaux	Dynamic conditional correlation model.	2001 - 2014			Fine wine is a hedge against movements in UK stocks.
LE FUR et al. (2016a) *Journal of Wine Economics*	Liv-ex indices Australia, Bordeaux, Burgundy, California, Champagne, Italy, Portugal, Rhone	Conditional CAPM, DCC GARCH.	2002 - 2013		Bordeaux wines present the greatest systematic risk.	
LE FUR et al. (2016b) *International Journal of Entrepreneurship and Small Business*	Liv-ex indices Australia, Bordeaux, Burgundy, California, Champagne, Italy, Portugal, Rhone	ADCC-GARCH	2003 - 2014	*Not investigated*	Wine indices are not affected in the same way by financial market volatility. The choice of the financial index strongly influences the identification of contagion effects.	*Not investigated*

Table 1 (con't)

Authors (year) *Source*	Data	Methodology used	Period	Performance		
				Returns	Volatility	Diversification
MASSET and WEISSKOPF (2016) *International Journal of Entrepreneurship and Small Business*	Steinfelds Auctions Bordeaux, Burgundy, Italy, Rhone Swiss market	RSR	2002 - 2012	Amplitude of returns strongly depends on wine regions and types. Bordeaux and Burgundy wines perform well. Wines from the Rhône valley and Italy show a poorer performance.		Wine outperforms stocks, but not bonds.
INTROVIGNE et al. (2017) *Risk Governance and Control: Financial Markets & Institutions*	Liv-ex indices Mediobanca Global Wine Industry Share Fine wine: Liv-ex 100 Fine Wine Normal wine: Mediobanca Global Wine Industry Share	Engle-Granger and Johansen tests	2001 - 2014	*Not investigated*	*Not investigated*	Wine indices have a higher Sharpe ratio compared to the general stock market index. There is no cointegration among the three indices and thus the existence of diversification benefits.
AYTAC et al. (2018) *Economic Modellling*	Monthly data from Liv-ex trading platform		2010 - 2015	Returns on wine investments appear profitable in 2010 and until mid-2011. The second half of 2012 was also a rewarding period. Apart for these two periods, the returns oscillate monthly between -2% and 2%.	Wine prices are less volatile than most asset classes. US equities strongly influence the dispersion of wine returns.	
BOURI et al. (2018) *Pacific-Basin Finance Journal*	Portfolio of different assets (US/UK equities, bonds, gold, housing)	Mean-variance and stochastic-dominance approaches				Investors prefer to invest in with-wine portfolios to gain higher expected utility when short sales are not allowed. Investors are indifferent between portfolios with(out) wine when short-selling is allowed.
MASSET and WEISSKOPF (2018) *Handbook of the Economics of Wine*	The Chicago Wine Company (auction data). More than 400,000 observations.	Index calculations using the RSR approach. Performance analyzed using the CAPM and the conditional CAPM.	1996 - 2009	Total return of 149% for a diversified wine index (63% for US wines; 198% for Bordeaux and 296% for Rhone) versus 42% for equities. Significant abnormal returns offered by wine investments.	Volatility of less than 15% for all wine indices and of just 8.2% for a diversified wine index; versus 17.9% for equities.	Low correlation between wine and equities. Beta is close to 0 or even slightly negative.
BEN AMEUR and LE FUR(2020) *Economic Modelling*	Liv-ex indices	ADCC-GARCH	2007 - 2017	*Not investigated*	In the short-term, volatility is transmitted with a negative effect through the financial and commodity markets and with a positive effect through the art, residential real estate, and credit default markets. In the long-term, the wine market is impacted by all other markets. Correlations are time-varying.	*Not investigated*

Table 2: Average price and trading activity per Château and year

Panel A	Average price														
	Left bank (Médoc and Graves)						Right bank (St-Emilion and Pomerol)							Sauternes	All
	Haut-Brion	Lafite Rothschild	Latour	Margaux	Mission Haut-Brion	Mouton Rothschild	Angélus	Ausone	Cheval Blanc	Lafleur	Pavie	Pétrus	Le Pin	Yquem	All
2003	287	265	424	272	354	313	99	175	387	650	94	938	968	480	370
2004	334	304	396	307	351	378	113	234	490	581	129	1'065	912	603	406
2005	403	362	538	355	453	385	129	257	576	898	130	1'284	1'142	661	491
2006	506	475	629	417	559	559	170	338	627	1'494	152	1'623	1'736	645	628
2007	613	796	768	613	685	663	168	642	925	1'140	209	1'994	2'062	984	794
2008	539	872	726	575	610	571	180	755	726	1'045	184	1'881	1'639	657	748
2009	542	914	672	499	577	598	180	832	679	869	197	1'731	1'683	610	723
2010	650	1'633	908	707	612	819	237	1'019	850	1'026	236	2'336	2'080	557	993
2011	709	1'593	1'021	712	694	827	264	928	758	1'071	254	2'514	2'161	599	1'055
2012	600	1'121	870	569	653	782	281	623	802	1'040	280	2'200	2'210	626	862
2013	685	1'079	867	592	591	766	298	673	791	1'038	296	2'556	2'303	493	903
2014	622	920	789	561	554	765	303	656	643	1'045	289	2'457	2'550	547	853
All	567	1'056	760	548	576	652	210	685	714	1'018	223	1'946	1'883	624	778

Panel B	Number of trades														
	Haut-Brion	Lafite Rothschild	Latour	Margaux	Mission Haut-Brion	Mouton Rothschild	Angélus	Ausone	Cheval Blanc	Lafleur	Pavie	Pétrus	Le Pin	Yquem	All
2003	775	914	968	856	402	1'115	198	118	515	155	108	723	79	426	9'080
2004	1035	1316	1242	1096	529	1600	211	125	620	220	148	849	100	487	12132
2005	989	1341	1265	1127	485	1980	228	180	795	201	183	914	83	562	13108
2006	967	1345	1286	1344	517	1686	187	185	860	284	204	1059	132	642	13656
2007	1255	1728	1474	1419	637	2017	283	204	880	313	178	1167	107	572	15154
2008	1567	2275	1777	1676	592	2210	293	255	868	346	278	1190	199	658	16872
2009	1282	1711	1317	1386	620	1687	182	214	918	272	279	951	124	496	13497
2010	1696	3253	2076	1977	848	2668	380	414	1149	349	470	1270	192	644	19917
2011	2041	4959	2654	2446	843	3382	431	438	1325	311	379	1470	176	690	23785
2012	1586	2691	1874	1786	760	2382	327	271	1136	238	393	1192	162	608	17730
2013	1288	1909	1326	1425	665	1732	241	239	776	250	309	950	162	626	13715
2014	1112	1641	1213	1108	532	1746	175	205	719	162	262	863	145	548	11973
All	15593	25083	18472	17646	7430	24205	3136	2848	10561	3101	3191	12598	1661	6959	180619

Table 3: Average price, number of trades and average rating per vintage (as of 2014)

	Average price	Number of trades	Average rating		Average price	Number of trades	Average rating
1945	5360.6	78	98.2	**1978**	537.7	100	86.3
1946	2069.0	1	N/A	**1979**	640.6	77	87.0
1947	3734.9	33	98.0	**1980**	397.6	19	87.2
1948	1485.5	17	94.8	**1981**	504.0	78	87.2
1949	2251.0	35	94.9	**1982**	1597.5	748	97.3
1950	1288.1	12	95.5	**1983**	538.5	179	92.5
1951	373.0	1	N/A	**1984**	615.2	27	84.0
1952	1006.1	19	87.0	**1985**	573.2	192	90.2
1953	894.9	24	96.5	**1986**	764.5	461	97.0
1954	711.3	6	N/A	**1987**	438.8	34	87.7
1955	1236.3	47	96.7	**1988**	661.2	273	91.2
1956	639.2	1	N/A	**1989**	1083.0	456	94.7
1957	538.4	8	87.0	**1990**	935.6	573	96.1
1958	469.3	4	70.0	**1991**	465.0	24	86.7
1959	1835.2	106	96.8	**1992**	533.6	35	87.9
1960	694.7	2	N/A	**1993**	486.1	111	89.5
1961	2386.8	114	96.7	**1994**	640.6	114	92.2
1962	930.8	24	90.5	**1995**	589.6	491	95.1
1963	718.4	3	N/A	**1996**	660.4	535	96.3
1964	734.8	64	85.0	**1997**	469.3	181	90.9
1965	498.4	2	N/A	**1998**	689.3	433	95.3
1966	666.7	77	88.2	**1999**	535.3	314	93.7
1967	925.0	55	85.8	**2000**	1198.3	723	98.6
1968	1064.0	2	N/A	**2001**	605.7	364	94.4
1969	579.5	5	68.0	**2002**	540.9	279	92.9
1970	725.1	154	89.5	**2003**	594.6	566	97.2
1971	919.0	37	89.6	**2004**	555.5	325	93.2
1972	350.5	5	N/A	**2005**	767.7	434	96.7
1973	552.6	16	76.2	**2006**	546.4	250	96.1
1974	753.1	16	78.5	**2007**	568.0	117	92.4
1975	779.1	147	93.7	**2008**	570.3	346	95.5
1976	576.7	72	89.4	**2009**	863.4	266	99.5
1977	425.8	12	69.2	**2010**	1231.6	107	98.9

Note: This table reports statistics on trading activity, price and rating per vintage. The column "Average rating" shows the average Robert Parker rating of all wines from a certain vintage traded in 2014; N/A indicates that no rating is available for any of the wines traded.

Table 4: Trading activity and types of wines (age, quality, price) traded in various locations

	North America				Europe				Asia			
	Average price	Number of trades	Average rating	% older than 20 years	Average price	Number of trades	Average rating	% older than 20 years	Average price	Number of trades	Average rating	% older than 20 years
2003	422.8	4534	93.8	48%	351.7	2818	92.7	41%				
2004	497.4	5817	94.1	46%	336.1	3761	92.9	35%				
2005	600.5	6399	94.7	45%	376.4	3934	92.4	43%				
2006	751.5	6472	94.5	52%	548.4	4226	92.7	44%				
2007	899.9	7979	95.0	46%	760.9	4255	93.1	38%				
2008	771.0	9180	94.6	40%	693.3	4058	93.1	45%	1'159.4	946	96.4	23%
2009	655.6	6183	94.7	43%	665.7	2877	93.7	40%	1'057.6	2379	96.0	32%
2010	922.1	8462	95.3	40%	808.5	3377	93.6	40%	1'361.1	5547	96.1	27%
2011	1'018.2	7820	95.0	55%	881.1	4499	93.1	45%	1'267.7	9226	95.4	44%
2012	905.6	5902	95.1	58%	806.5	3691	93.4	50%	953.9	5813	95.6	40%
2013	815.3	5159	95.1	48%	848.4	3244	93.7	52%	1'145.5	3495	95.7	42%
2014	855.4	4332	94.5	54%	769.2	2819	94.2	41%	982.7	3280	95.6	33%
All	777.8	78239	94.7	47%	656.8	43559	93.2	43%	1'161.1	30686	95.7	37%

Note: This table reports statistics on trading activity and the types of wines (age, quality - measured by Robert Parker ratings, and price) traded in North America, Europe and Asia.

Table 5: List of variables used in hedonic regressions

Variables	Details	Used in Specification 1	Used in Specification 2	Used in Specification 3
A. Variables specific to the wine auctioned :				
Château	Dummy variables each Château	×	×	×
Vintage	Dummy variables for vintages 1945 to 2010			×
Age	Age of the wine	×		
Age × Vintage quality	Interaction term between age and a set of vintage quality dummy variables		×	
Rating	Parker rating	×	×	×
$Rating^2$	Squared Parker rating	×	×	×
B. Variables specific to to a particular transaction :				
Time of sale	Dummy variables for January 2003 to December 2015 (used to construct the index)	×	×	×
Auction house	Dummy variables for Acker Merrall & Condit, Bonhams, Christie's, Hart Davis Hart, Morrell, Sotheby's, Spectrum and Zachy's	×	×	×
Auction location	Dummy variables for North America, Europe and Asia	×	×	×
Quantity	Number of bottles sold in a particular lot	×	×	×
OWC-6	Dummy variable to control if the wine is sold in the 6-bottle Original Wooden Case (OWC)	×	×	×
OWC-12	Same as OWC-6 but for 12-bottle OWC.	×	×	×

Note: This table shows the three hedonic regression specifications that are used in the paper. The variables used in each specification are indicated in the column denoted as "used in specification 1 to 3". In specification 2, a set of vintage quality dummy variables (five dummy variables, for poor to great vintages) is used to model the joint effect of age and vintage's quality on prices.

Table 6: Coefficient estimates from hedonic regressions

	Specification 1		Specification 2		Specification 3	
	Coeff.	**p-value**	**Coeff.**	**p-value**	**Coeff.**	**p-value**
Intercept	-0.0069	84.08%	0.8729	0.00%	1.7127	0.00%
Ausone	0.9704	<0.01%	0.9528	0.00%	0.9473	0.00%
Cheval Blanc	0.9470	<0.01%	0.9308	0.00%	0.9182	0.00%
Haut-Brion	0.6363	<0.01%	0.6860	0.00%	0.6946	0.00%
Lafite Rothschild	1.1210	<0.01%	1.1836	0.00%	1.2281	0.00%
Lafleur	1.1175	<0.01%	1.1878	0.00%	1.2234	0.00%
Latour	0.8540	<0.01%	0.8970	0.00%	0.9392	0.00%
Margaux	0.6838	<0.01%	0.7397	0.00%	0.7878	0.00%
Mission Haut-Brion	0.3778	<0.01%	0.4384	0.00%	0.4348	0.00%
Mouton Rothschild	0.7050	<0.01%	0.7417	0.00%	0.7670	0.00%
Pavie	-0.0103	36.40%	-0.0419	0.00%	-0.0968	0.00%
Pétrus	1.8877	<0.01%	2.0048	0.00%	2.0770	0.00%
Le Pin	2.0822	<0.01%	2.1347	0.00%	2.1822	0.00%
Yquem	0.5424	<0.01%	0.6835	0.00%	0.7549	0.00%
Age	0.0235	<0.01%				
Age × Poor vintage			0.0153	0.00%		
Age × Average vintage			0.0056	0.00%		
Age × Good vintage			0.0103	0.00%		
Age × Very good vintage			0.0113	0.00%		
Age × Outstanding vintage			0.0293	0.00%		
Rating	-0.0046	<0.01%	-0.0036	0.00%	-0.0028	0.00%
$Rating^2$	0.0006	<0.01%	0.0004	0.00%	0.0004	0.00%
Bonhams	-0.1360	<0.01%	-0.1269	0.00%	-0.1192	0.00%
Christie's	-0.0226	<0.01%	-0.0302	0.00%	-0.0246	0.00%
Hart Davis Hart	-0.0321	<0.01%	-0.0340	0.00%	-0.0264	0.00%
Morrell	-0.2235	<0.01%	-0.2213	0.00%	-0.1975	0.00%
Sotheby's	0.0259	<0.01%	0.0127	0.14%	0.0124	0.04%
Spectrum	-0.1420	<0.01%	-0.1347	0.00%	-0.1241	0.00%
Zachy's	-0.0520	<0.01%	-0.0562	0.00%	-0.0529	0.00%
Europe	-0.0464	<0.01%	-0.0433	0.00%	-0.0272	0.00%
Hong-Kong	0.2005	<0.01%	0.1797	0.00%	0.1655	0.00%
Quantity	-0.0070	<0.01%	-0.0050	0.00%	-0.0037	0.00%
OWC-6	0.0143	0.06%	0.0219	0.00%	0.0205	0.00%
OWC-12	-0.0156	<0.01%	0.0007	83.12%	0.0180	0.00%
Vintage Fixed Effects	No		No		Yes	
Observations :	152484		152484		152484	
R^2 :	0.75	<0.01%	0.80	<0.01%	0.84	<0.01%

Note: the reference (intercept) is Angélus 2010 sold in the USA by Acker Merrall & Condit in January 2003.

Table 7: Descriptive statistics

Panel A	General Wine index, equity market and risk factors					
	All wines	MKT	MKT - Rf	LIQ	RX_{FX}	HML_{FX}
Average	10.9%	8.4%	7.0%	5.4%	2.4%	6.3%
Volatility	29.2%	14.0%	14.0%	12.8%	6.7%	7.9%
Skewness	0.46	-0.88	-0.84	-0.47	-0.54	-0.47
Kurtosis	3.39	5.43	5.36	4.45	4.41	3.94
Autocorrelation	-0.26	0.18	0.19	0.13	0.03	0.12

Panel B	Wine subindices					
	≤ 20 years old	> 20 years old	≥ 95 points	< 95 points	Left Bank	Right Bank
Average	12.0%	10.8%	11.5%	10.1%	11.9%	11.6%
Volatility	26.6%	33.6%	30.3%	27.1%	31.0%	32.6%
Skewness	0.27	0.46	0.59	0.20	0.71	0.25
Kurtosis	3.54	3.62	5.77	3.09	4.28	3.90
Autocorrelation	-0.35	-0.26	-0.33	-0.15	-0.24	-0.29

Note: this table contains descriptive statistics for the general wine index, equity market and risk factors (panel A), and wine subindices (panel B).

Table 8: Time-series regressions for the general wine index

Panel A: Monthly data	CAPM				Liquidity-augmented CAPM				Liquidity & FX-augmented CAPM			
α	0.8%	0.66%	0.58%	0.58%	0.64%	0.51%	0.42%	0.33%	0.57%	0.42%	0.24%	0.13%
ϱ	-0.26*	-0.28*	-0.29*	-0.29*	-0.25*	-0.28*	-0.29*	-0.3*	-0.23*	-0.3*	-0.31*	-0.32*
β	0.3*	0.24	0.24	0.24	0.24	0.2	0.18	0.16	-0.2	-0.31	-0.32	-0.28
$\beta_{lag\ 1}$		0.33*	0.3*	0.3*		0.27	0.25	0.17		0.11	0.03	-0.05
$\beta_{lag\ 2}$			0.18	0.17			0.13	0.14			0.19	0.22
$\beta_{lag\ 3}$				0.02				0				0.06
Total β	0.3*	0.47*	0.61	0.56	0.24	0.39	0.47	0.36	-0.2	-0.17	-0.09	-0.03
λ					0.41*	0.35*	0.36*	0.38*	0.38*	0.28	0.29	0.33*
$\lambda_{lag\ 1}$						0.12	0.09	0.12		0	-0.01	0.05
$\lambda_{lag\ 2}$							0.12	0.08			0	-0.02
$\lambda_{lag\ 3}$								0.36*				0.27
Total λ					0.41*	0.42	0.52	0.91	0.38*	0.25	0.25	0.61
γ									1.29*	1.34*	1.39*	1.4*
$\gamma_{lag\ 1}$										0.94*	1.01*	1.06*
$\gamma_{lag\ 2}$											-0.19	-0.28
$\gamma_{lag\ 3}$												-0.45
Total γ									1.29*	2.23*	2.16*	1.42*
θ									0.16	0.3	0.3	0.2
$\theta_{lag\ 1}$										-0.08	-0.09	-0.11
$\theta_{lag\ 2}$											0.32	0.22
$\theta_{lag\ 3}$												0.35
Total θ									0.16	0.2	0.47	0.56
Nobs.	142	142	142	142	142	142	142	142	142	142	142	142
R^2	0.09	0.11	0.12	0.12	0.12	0.14	0.15	0.17	0.18	0.23	0.24	0.27

Panel B: Quarterly data	CAPM				Liquidity-augmented CAPM				Liquidity & FX-augmented CAPM			
α	1.48%	1.45%			1.26%	1.14%			1.24%	1.05%		
ϱ	-0.25*	-0.26			-0.27*	-0.31*			-0.28*	-0.3*		
β	0.64*	0.64*			0.59*	0.58*			0.25	0.17		
Delta Q - M	0.35**				0.34				0.45			
$\beta_{lag\ 1}$		0.02				0.1				0.26		
Total β	0.64*	0.55*			0.59*	0.55*			0.25	0.35		
λ					0.27	0.3			0.21	0.23		
$\lambda_{lag\ 1}$						-0.01				-0.1		
Total λ					0.27	0.35			0.21	0.15		
γ									1.2*	1.33*		
$\gamma_{lag\ 1}$										-0.23		
Total γ									1.2*	1.01*		
θ									0.01	0.09		
$\theta_{lag\ 1}$										-0.02		
Total θ									0.01	0.07		
Nobs.	46	46			46	46			46	46		
R^2	0.26	0.26			0.30	0.31			0.43	0.46		

Note: this table reports the results from the time-series regressions for the general wine index. The loadings on the various risk factors are computed using up to three lags for monthly data (Panel A) and up to one lag for quarterly data (Panel B). The total loadings are adjusted for serial autocorrelation in the risk factor and their significativity is assessed via a Wald F-test. Delta Q-M reports the difference between the loading with respect to MKT for quarterly data comapred to monthly data. "***", "**" and "*" denote significance at the 99%, 95% and 90%-level respectively.

Table 9: Time-series regressions for sub-indices (age, rating, area of production)

Panel A: Monthly data	Liquidity & FX-augmented CAPM								
	≤ 20 years old	> 20 years old	Delta Age	≥ 95 points	< 95 points	Delta Points	Left Bank	Right Bank	Delta Bank
α	0.38%	0.22%	-0.05%	0.11%	0.14%	-0.19%	0.27%	0.46%	-0.36%
ρ	-0.45***	-0.27***	-0.42***	-0.39***	-0.23**	-0.37***	-0.32***	-0.32***	-0.44***
β	-0.13	-0.36	0.22	-0.17	-0.08	-0.13	-0.2	-0.28	0.04
$\beta_{lag\ 1}$	-0.21	0.06	-0.18	-0.11	-0.08	0.01	-0.04	0.15	-0.14
$\beta_{lag\ 2}$	0.12	0.33	-0.24	0.12	0.16	-0.03	0.13	0.42	-0.31
$\beta_{lag\ 3}$	0.15	-0.06	0.19	0.17	0.14	0.02	0.13	0	0.11
Total β	-0.05	-0.02	0	0	0.1	-0.1	0.02	0.23	-0.23
λ	0.21	0.45*	-0.19	0.26	0.24	0.03	0.28	0.34	-0.11
$\lambda_{lag\ 1}$	0.11	-0.01	0.02	0.17	0.03	0.08	0.1	-0.09	0.18
$\lambda_{lag\ 2}$	-0.13	0.13	-0.23	-0.18	0.07	-0.24	-0.1	-0.12	0.04
$\lambda_{lag\ 3}$	0.12	0.34	-0.25	0.09	0.15	-0.08	0.18	0.4*	-0.24
Total λ	0.3	0.87	-0.63	0.33	0.47	-0.2	0.45	0.51	-0.13
γ	0.73*	1.37**	-0.52	1.28***	1.05**	0.38	1.35***	0.89*	0.46
$\gamma_{lag\ 1}$	1.38***	0.57	0.52	0.86*	1.14**	-0.5	1.22**	0.65	0.62
$\gamma_{lag\ 2}$	0	-0.13	0.09	0.16	0.21	-0.17	0	-0.74	0.78
$\gamma_{lag\ 3}$	-0.73*	-0.28	-0.48	-0.74	-0.29	-0.48	-0.48	-0.19	-0.21
Total γ	1.13***	1.27	-0.32	1.28**	1.74**	-0.63	1.72***	0.51	1.36
θ	0.37	0.14	0.18	0.16	0.14	-0.02	0.09	0.25	-0.08
$\theta_{lag\ 1}$	0.25	0.18	0.03	0.29	-0.41	0.68**	-0.32	0.41	-0.79**
$\theta_{lag\ 2}$	0.37	-0.58	0.91**	0.28	0.18	0.16	0.45	-0.24	0.58
$\theta_{lag\ 3}$	0.08	0.57	-0.44	0.3	0.32	-0.09	0.34	-0.01	0.45
Total θ	0.9	0.25	0.57	0.88	0.19	0.61	0.47	0.35	0.13*
Nobs.	142	142	142	142	142	142	142	142	142
R^2	0.34	0.24	0.30	0.29	0.22	0.22	0.24	0.24	0.29

Panel B: Quarterly data	Liquidity & FX-augmented CAPM								
	≤ 20 years old	> 20 years old	Delta Age	≥ 95 points	< 95 points	Delta Points	Left Bank	Right Bank	Delta Bank
α	1.39%	0.88%	0.44%	0.99%	1.49%	-0.88%	1.11%	1.46%	-0.57%
ρ	-0.21	-0.44***	-0.54***	-0.2	-0.33*	-0.61***	-0.18	-0.48***	-0.3*
β	0.03	0.28	-0.18	0.15	0.21	-0.07	0.15	0.39*	-0.08
$\beta_{lag\ 1}$	0.21	0.21	0.03	0.2	0.11	0.17	0.27	-0.16	0.45**
Total β	0.2	0.4	-0.12	0.29	0.26	0.08	0.34	0.19	0.31*
λ	0.17	0.3	-0.07	0.19	0.27	-0.06	0.28	0.01	0.32**
$\lambda_{lag\ 1}$	-0.17	0.04	-0.19	-0.09	-0.13	0.01	-0.11	-0.22	0.15
Total λ	0	0.41	-0.31	0.12	0.18	-0.06	0.2	-0.25	0.56
γ	1.66***	0.88*	0.83**	1.29***	1.47***	-0.11	1.48***	1.12***	0.34
$\gamma_{lag\ 1}$	-0.42	-0.17	0.09	-0.54	-0.06	-0.42	-0.57	0.36	-0.61
Total γ	1.13***	0.64	0.84	0.68**	1.28***	-0.48	0.83***	1.35**	-0.25
θ	-0.01	0.45	-0.63*	0.01	-0.05	-0.01	-0.01	0.2	-0.4
$\theta_{lag\ 1}$	0.3	-0.18	0.38	0.23	-0.03	0.2	0.14	0.36	-0.19
Total θ	0.29	0.27	-0.25	0.24	-0.08	0.19	0.12	0.55	-0.59
Nobs.	46	46	46	46	46	46	46	46	46
R^2	0.44	0.46	0.43	0.40	0.50	0.42	0.47	0.51	0.30

Note: this table reports the results from the time-series regressions for three pairs of wine subindices (defined on the basis of age, rating, and area of production) as well as for the difference between each pair. The loadings on the various risk factors are computed using up to three lags for monthly data (Panel A) and up to one lag for quarterly data (Panel B). The total loadings are adjusted for serial autocorrelation in the risk factor and their significance is assessed via a Wald F-test. "***", "**" and "*" denote significativity at the 99%, 95% and 90%-level respectively.

Table 10: Time-series regressions for individual wine ("Château") subindices

Panel A: Monthly data	Liquidity & FX-augmented CAPM													
	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
α	1.29%	1.73%	0.29%	0.26%	0.29%	1.4%	0.52%	0.24%	0.57%	0.64%*	0.39%	0.55%	1.71%	-0.07%
ϱ	-0.47***	-0.33***	-0.47***	-0.45***	-0.3***	-0.35***	-0.28***	-0.31***	-0.41***	-0.34**	-0.34***	-0.47**	-0.36**	-0.37
β	0.21	-0.02	-0.21	0.04	-0.12	-0.07	0.15	-0.04	0.21	-0.2	-0.08	0.07**	-0.09	-0.25
$\beta_{lag\ 1}$	-0.25	0.75	0.03	-0.09	0.04	-0.58	-0.04	0.05	-0.27	-0.1	-0.14	-0.32**	0.1	-0.11
$\beta_{lag\ 2}$	0.26	0.31	0.36	-0.11	-0.03	0.44	-0.08	0.12	0.26	0.01	0**	0.36	0.21	0.11
$\beta_{lag\ 3}$	-0.09	-0.34	0.25	0.07	0.06	0.07	0.38	-0.03	0.16	0.36*	0.44	0.06	0.32	0.04
Total β	0.09	0.53	0.33	-0.07	-0.03	-0.11	0.32	0.08	0.28	0.06	0.18	0.13	0.42	-0.16
λ	0.32	0.88**	0.13	0.02	0.43**	0.18	0.18	0.11	0.65**	0.22***	0.66	0.26**	0.21***	0.23**
$\lambda_{lag\ 1}$	0.29	-0.08	0.15	0.27	0.11	0.04	0.17	0.02	-0.1	0.02	-0.14	-0.25	0.39	-0.21
$\lambda_{lag\ 2}$	-0.18	0.05	-0.35	-0.19	0.04	0.08	-0.22	-0.11	-0.25	-0.26	-0.38	0.04	-0.18	0.26
$\lambda_{lag\ 3}$	-0.11	0.46	0.27	0.03	-0.18	0.51	0.25	0.26	0.03	0.2	0.36	0.22	0.45	0
Total λ	0.31	1.27	0.19	0.13	0.39	0.77	0.38	0.26	0.32	0.17	0.48**	0.26	0.84	0.27
γ	1.32**	0.59	0.35	0.67	0.99*	0.92	1.1*	0.69	0.49	1.71	1.72	0.32	1.03	0.59
$\gamma_{lag\ 1}$	1.12*	-0.12	1.06*	1.42***	0.89*	0.97	0.63	0.96*	1.24*	0.64	1.04	1.34	-0.38	0.51
$\gamma_{lag\ 2}$	-0.26	0.19	-0.12	0.74	0.3	-0.66	1.12*	0.12	-0.5	0.26	-0.23	0.45	0.03	0.21
$\gamma_{lag\ 3}$	-1.27**	-0.09	-0.06	-0.48	-0.05	0.16	-1.03	-0.13	-0.98	-0.39	-0.47	-0.36	-0.68	-0.5
Total γ	0.75**	0.46	1.01	1.93***	1.75	1.14	1.5*	1.35	0.21	1.83	1.69**	1.44*	0	0.67
θ	-0.68	-0.67	0.41	0.26	0.05	-0.12	-0.28	0.46	0.08	-0.21	-0.53	0.51	-1.25	0.26
$\theta_{lag\ 1}$	0.19	-0.39	0.16	-0.29	0.33	0.69	-0.19	-0.25	0.46	0.33	0.07	0.26	0.64	-0.07
$\theta_{lag\ 2}$	-0.18	-1.03	0.32	0.3	0.32	-0.25	0.21	0.12	-0.09	0.85	0.98	-0.44	-0.01	0.61
$\theta_{lag\ 3}$	0.99**	1.14	-0.03	0.69*	0.48	-0.35	0.47	0.05	0.93*	-0.16	-0.66	0.29	0.34	0.52
Total θ	0.27	-0.8	0.73	0.81	1	-0.02	0.18	0.32	1.16	0.68	-0.12	0.53	-0.24	1.11
Nobs.	142	142	142	142	142	142	142	142	142	142	142	142	142	142
R^2	0.33	0.23	0.29	0.33	0.24	0.19	0.21	0.19	0.30	0.21	0.31	0.32	0.19	0.24
Panel B: Quarterly data	**Liquidity & FX-augmented CAPM**													
	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**	**W11**	**W12**	**W13**	**W14**
α	2.88%*	1.91%	0.73%	1.34%	1.36%	3.62%	0.71%	0.73%	1.56%	1.39%	1.88%	1.17%	2.89%	-0.14%
ϱ	-0.33**	-0.55***	-0.34**	-0.36**	0.02	-0.45***	-0.06	-0.18	-0.42***	-0.31	-0.75	-0.41	-0.38	-0.43
β	0.15	0.24	0.65**	0.16	0.11	-0.36	0.12	0.09	0.26	0.09	0.23	0.31	0.54	0.11
$\beta_{lag\ 1}$	0.32	0.19	-0.52**	0.11	-0.08	0.35	0.26	0.23	0.16	0.27	0.42	-0.09	-0.12	0.07
Total β	0.39	0.35	0.11**	0.22	0.02	0	0.32	0.26	0.35	0.29	0.54*	0.18	0.34	0.15
λ	-0.04	0.56**	0.12	0.14	0.24	0.02	0.25	0.12	0.31*	0.14	0.23	-0.02	0.23	0.07
$\lambda_{lag\ 1}$	-0.35*	-0.18	-0.08	0.02	-0.38	-0.61	-0.32	-0.22	0.02	-0.2	0	-0.29	-0.17	-0.25
Total λ	-0.46	0.46**	0.05	0.2	-0.16	-0.71	-0.08*	-0.12	0.39	-0.07	0.27	-0.37	0.06	-0.23
γ	1.37***	0.87	1.1**	1.57***	1.31**	0.65	1.25***	1.3***	1.08***	1.14	1.63	1.48	1.85	0.31
$\gamma_{lag\ 1}$	-0.14	0.68	0.25	-0.26	0.39	0.64	-0.32	-0.21	-0.29	-0.03	0.2	-0.01	0.21	0.16
Total γ	1.13**	1.41	1.23*	1.2***	1.56*	1.18	0.85**	0.99**	0.72**	1.01	1.67***	1.34***	1.88*	0.43
θ	-0.27	-0.4	-0.21	-0.15	0.38	1.44	0.1	0.09	0.03	0.37	-0.37	0.03	0.09	0.21
$\theta_{lag\ 1}$	-0.11	0.17	0.65	0.2	0.25	-0.7	0.22	0.08	-0.05	-0.04	0	0.85	0.02	0.21
Total θ	-0.38	-0.23	0.44	0.05	0.64	0.74	0.31	0.17	-0.01	0.33	-0.37	0.87*	0.11	0.42
Nobs.	46	46	46	46	46	46	46	46	46	46	46	46	46	46
R^2	0.40	0.45	0.51	0.45	0.36	0.30	0.46	0.36	0.57	0.34	0.67	0.51	0.51	0.23

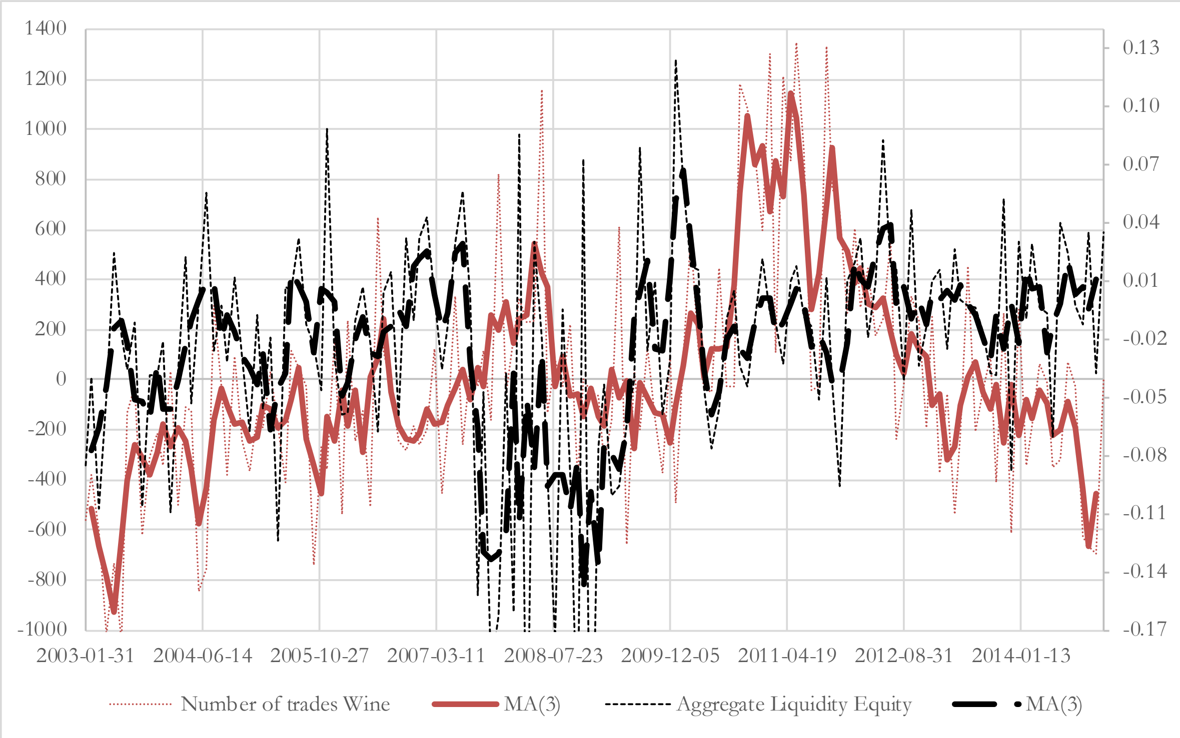
Note: this table reports the results from time-series regressions for individual wine ("Château") subindices (which are respectively, from W1 to W14, Angélus, Ausone, Cheval Blanc, Haut-Brion, Lafite Rothschild, Lafleur, Latour, Margaux, Mission Haut-Brion, Mouton Rothschild, Pavie, Pétrus, Le Pin and Yquem). The loadings on the various risk factors are computed using up to three lags for monthly data (Panel A) and up to one lag for quarterly data (Panel B). The total loadings are adjusted for serial autocorrelation in the risk factor and their significance is assessed via a Wald F-test. "***", "**" and "*" denote significativity at the 99%, 95% and 90%-level respectively.

Table 11: Fama-MacBeth cross-sectional regressions

Panel A: CAPM	**(1) wine style**		**(2) individual wine**	
	8 portfolios		**14 portfolios**	
Constant	2.17%	(1.13)	2.14%	(1.17)
MKT	2.25%	(0.85)	2.31%	(0.88)
Panel B: Liquidity-augmented CAPM	**(1) wine style**		**(2) individual wine**	
	8 portfolios		**14 portfolios**	
Constant	2.84%	(1.32)	2.06%	(1.15)
MKT	2.03%	(0.78)	1.74%	(0.62)
LIQ	-1.55%	(-0.32)	2.18%	(1.05)
Panel C: Liquidity & FX risk-augmented CAPM	**(1) wine style**		**(2) individual wine**	
	8 portfolios		**14 portfolios**	
Constant	2.67%	(0.79)	1.61%	(0.94)
MKT	1.84%	(0.69)	1.18%	(0.33)
LIQ	-2.79%	(-0.54)	2.06%	(0.86)
RX	0.91%	(0.43)	1.24%	(1.21)
HML	2.2%	(0.6)	1.83%	(0.86)

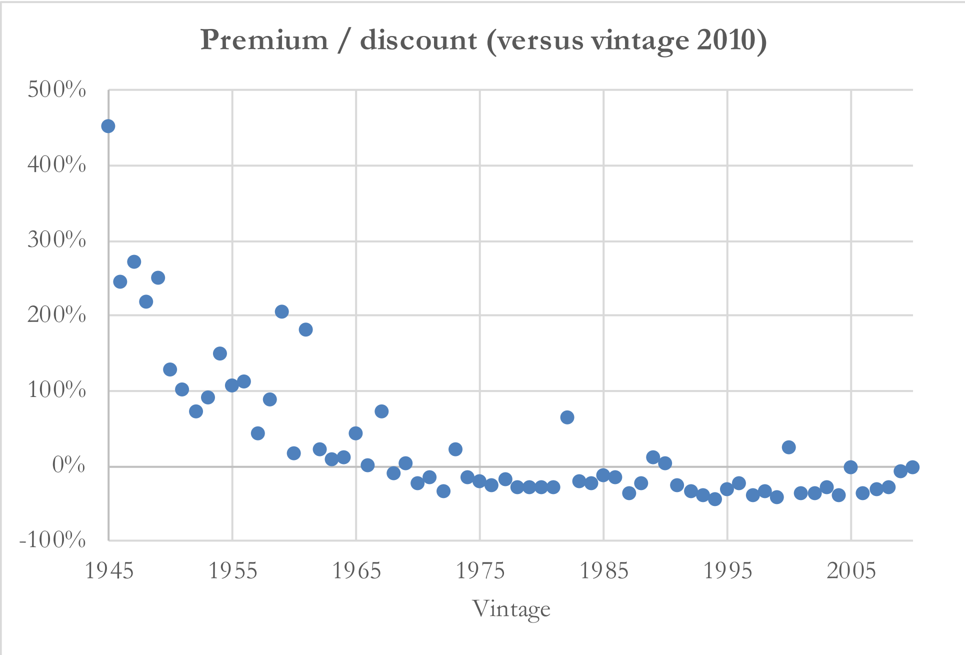
Notes: The table presents Fama-MacBeth regression results for quarterly data on (1) 8 wine style portfolios built on the basis of area of production (left and right bank), scores (above 95 points and below or equal to 95 points), age (less than 20 years old and 20 years old or more); and (2) 14 individual wine portfolios built on the basis of the wine producers (14 Châteaux). T-stats are reported in brackets in the column

Figure 1: Liquidity on wine and stock markets



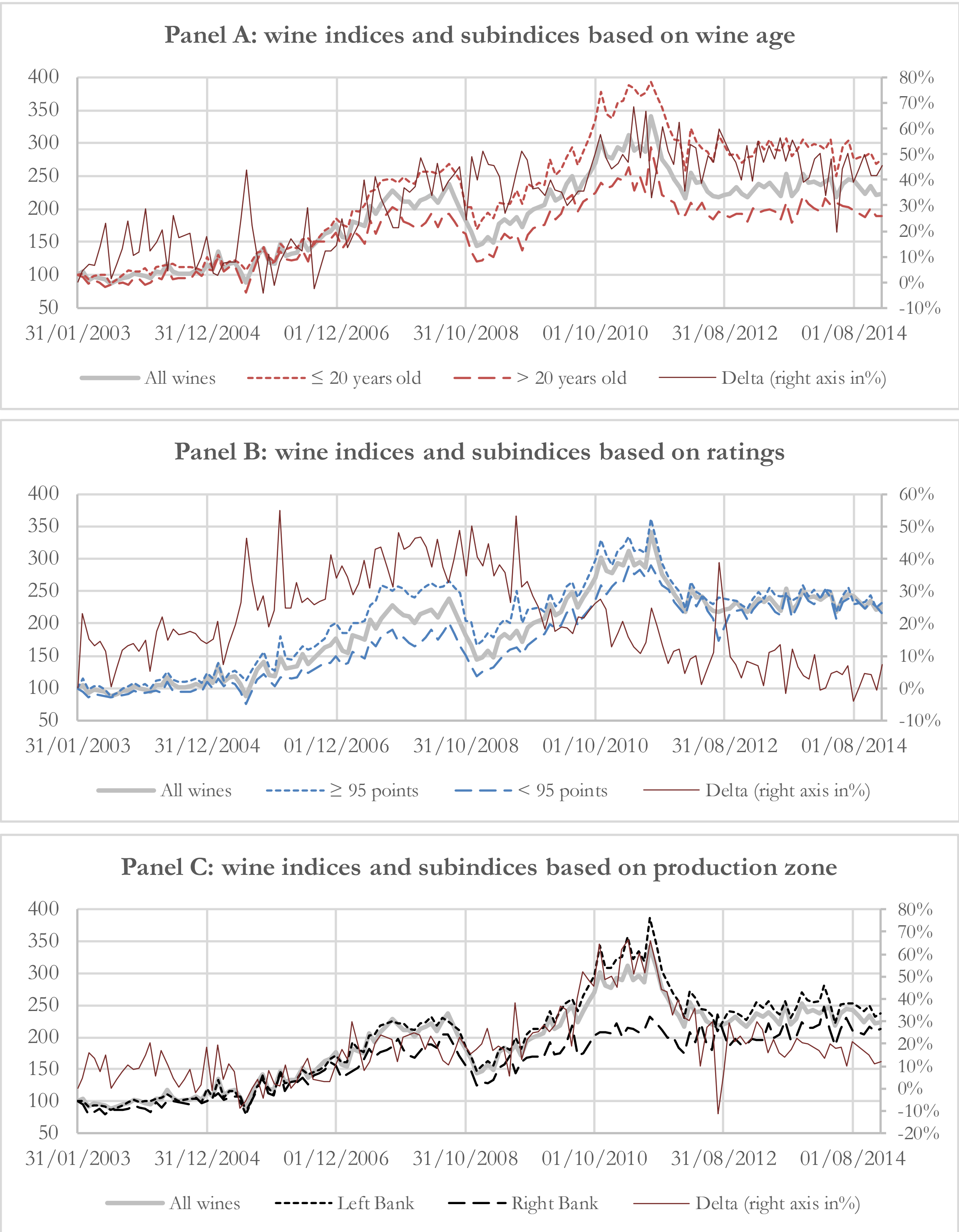
Notes: this figure reports the number of trades on the wine market and the aggregate liquidity on the U.S. equity market (http://finance.wharton.upenn.edu/~stambaug/liq_data_1962_2019.txt) as well as their simple centred 3-month moving averages.

Figure 2: Vintage effect



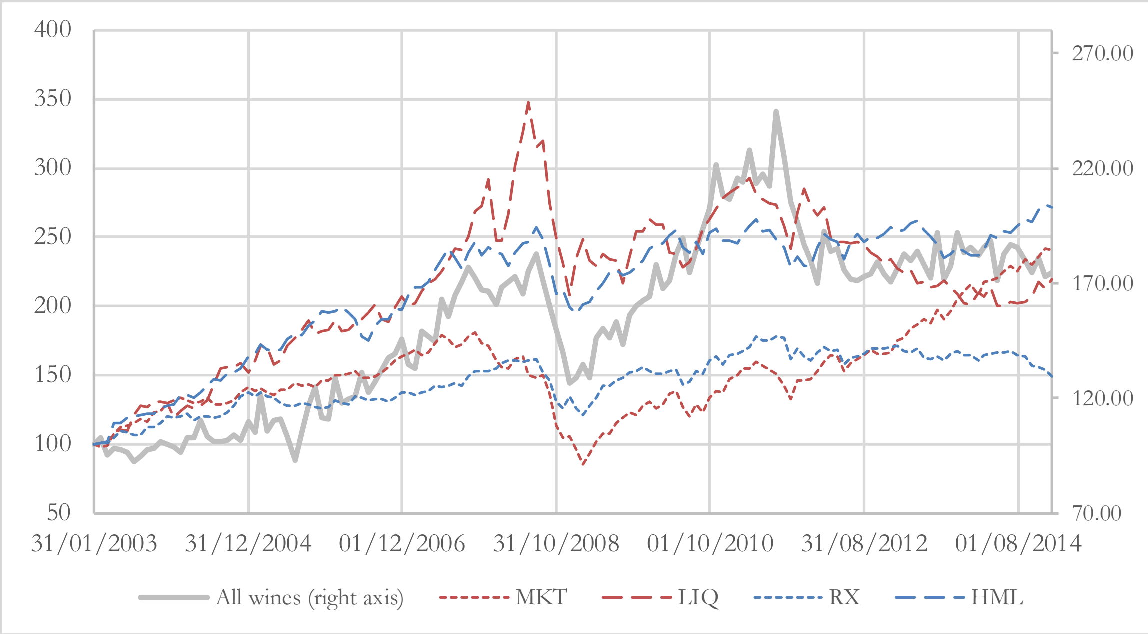
Note: this figure shows the vintage effect reported as a premium / discount as compared to vintage 2010. The effect is computed as the exponential of the vintage dummy coefficients (from specification 3) minus 1.00

Figure 3: Evolution of the wine index and six subindices



Note: This figure contrasts the evolution of a general wine index (reported in bold grey) with subindices defined on the basis of wine age (Panel A), ratings (Panel B), and production zone (Left or Right bank) (Panel C). The fine continuous line shows the difference expressed in percentage between each pair of subindices (reported on the right vertical axis).

Figure 4: Wine index and common risk factors



Note: this figure contrasts the evolution of the general wine index with common risk factors, including market risk (MKT, proxied by the S&P 500), Liquidity risk (LIQ, Pastor & Stambaugh, 2003), and exchange rate risk (RX and HML, Lustig, Roussanov & Verdelhan 2011).