# The price of wine[†]

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## Abstract

Using historical price records for Bordeaux Premiers Crus, we examine the impact of aging on wine prices and the long-term investment performance of fine wine. In line with the predictions of an illustrative model, young maturing wines from high-quality vintages provide the highest financial returns. Past maturity, famous châteaus deliver growing non-pecuniary benefits to their owners. Using an arithmetic repeat-sales regression over 1900–2012, we estimate a real financial return to wine investment (net of storage costs) of 4.1%, which exceeds bonds, art, and stamps. Returns to wine and equities are positively correlated. Finally, we find evidence of in-sample return predictability.

*JEL classification*: C43; D44; G11; G12; Q11; Z11.

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## 1. Introduction

Among wealthy individuals, fine wine is a popular investment. About one-quarter of high net worth individuals around the world own a wine collection, which on average represents 2% of their wealth (Mitchell, 2012). Many wine funds have sprung up to satisfy the increasing demand to invest in fine wines. In light of the long-standing yet rising status of high-end wines as an investment—and given the debate on the role of alternative investments in portfolio choice more generally (e.g., Swensen, 2000; Ang, Papanikolaou, and Westerfield, 2014)—a study of long-term price trends in this market and a comparison with more traditional assets is timely.

A small literature exists on the returns to storing wine, but the findings are mixed and depend on the period being investigated. Based on four years of auction data, Krasker (1979) finds that average returns to holding red Bordeaux and California wines are no larger than returns on Treasury bills after transaction costs. Jaeger (1981) expands the time frame by four years and finds the opposite. Later studies apply more sophisticated methods for constructing prices indexes, but they also work with 15 years of data or less. Burton and Jacobsen (2001), for example, estimate returns on red Bordeaux wines from 1986 to 1996 and find returns to be low and relatively volatile. Examining the subsequent decade, Lucey and Devine (2015) find that their Bordeaux and Rhone wine indexes yield returns in excess of Treasury bills and with risk below the stock market. Masset and Weisskopf (2010) study a number of wines from 1996 to 2009 and conclude that adding wine to an investment portfolio can increase its return while lowering risk. Kourtis, Markellos, and Psychoyios (2012) reach similar conclusions in a study of wine prices from 2001 to 2010.

By considering historical prices over many decades, we bring a longer-term perspective to studying the price dynamics of fine wine. Our work is in the spirit of recent research on the performance of other emotional assets such as art (e.g., Goetzmann, 1993; Mei and Moses, 2002), stamps (Dimson and Spaenjers, 2011), or violins (Graddy and Margolis, 2011). It can also be compared with studies of

long-term equity and bond returns (e.g., Schwert, 1990; Siegel, 1992; Jorion and Goetzmann, 1999; Dimson, Marsh, and Staunton, 2002) and vintage effects in equities (Jovanovic and Rousseau, 2001).

Furthermore, we investigate how aging affects wine prices independently of changes in market conditions. Identifying the effects of aging requires separating them not only from time effects but also from effects related to particular vintages, and this is another dimension upon which our contribution is unique. A few studies on cross-sectional variation in wine prices show that older wines tend to command higher prices (Di Vittorio and Ginsburgh, 1996; Ashenfelter, 2008) but do not separate effects of vintage quality from age.

One reason that it is interesting to look at the effects of aging on prices and returns is that even wines which have lost their gastronomic appeal can be valuable if they provide enjoyment and pride to their owners. By estimating life-cycle price patterns, we examine if and when nonfinancial ownership dividends codetermine price levels for well-known wines. Considering such non-pecuniary benefits along with pure financial returns is relevant from a broader asset pricing perspective. For example, nonfinancial utility could also play a role in markets for entrepreneurial investments (Moskowitz and Vissing-Jørgensen, 2002), prestigious hedge funds (Statman, Fisher, and Anginer, 2008), socially responsible mutual funds (Bollen, 2007; Renneboog, Ter Horst, and Zhang, 2011), social, environmental, and ethical portfolios (Dimson, Karakaş, and Li, 2014), and art (Stein, 1977; Mandel, 2009). Heinkel, Kraus, and Zechner (2001) and Hong and Kacperczyk (2009) show that the non-pecuniary disadvantages associated with holding particular assets could also affect expected returns.

We begin by presenting a simple and stylized model of price dynamics that accounts for fluctuations in a famous wine's consumption value and attractiveness as a collectible over its life. The model proposes that, in general, a wine's fundamental value is governed by the maximum of three measures: (1) the value of immediate consumption, (2) the present value of consumption at maturity plus the nonfinancial ownership dividends received until consumption, and (3) the present value of lifelong

storage (i.e., the value as a collectible). The model ties the values of consumption and ownership dividends to financial wealth, which reflects the discretionary nature of luxury goods (Goetzmann and Spiegel, 1995; Aït-Sahalia, Parker, and Yogo, 2004). It also implies that, abstracting from changes in quality, the price appreciation of wines over time is determined by the growth rate of wealth. Cross-sectionally, the model delivers different predictions for the price patterns of low-quality and high-quality vintages of superstar châteaus over their respective life cycles. The consumption value of a low-quality vintage declines quickly after bottling and leads to a fall in prices. This persists until the present value of the enjoyment associated with infinite ownership of the wine (storing without the goal of ever drinking) exceeds that of consumption, at which point prices start rising with age. Prices of high-quality vintages, which improve in quality after bottling, rise strongly until maturity and then stabilize. Eventually, as these wines begin to be regarded as collectibles instead of consumption goods, prices advance again. For all wines, financial returns reflect the effects of both wealth growth and aging on prices. The expected financial return on wine is always below the appropriate discount rate because the nonfinancial ownership dividends received while storing a bottle endogenously lower the required capital gain. This is especially relevant for wines that are long beyond maturity, as their fundamental values are determined by their value as collectibles (i.e., by the future stream of ownership dividends) and not by their consumption value.

We next describe a unique historical database of prices for five long-established Bordeaux wines: Haut-Brion, Lafite-Rothschild, Latour, Margaux, and Mouton-Rothschild—the Premiers Crus or First Growths. We construct this database using two types of price information: transaction prices realized at auctions organized by Christie's London and retail list prices of the London-based wine dealer Berry Bros. & Rudd (BBR). The data are hand-collected from various sources, including archived auction catalogues, dealer price lists, and company publications and websites. The database contains 36,271

prices for 9,492 combinations of sale year (e.g., 2007), château (e.g., Latour), vintage year (e.g., 1982), and transaction type (dealer or auction) from end-1899 through end-2012.

We then use this new data set to study the returns to holding wine and the effects of aging on wine prices. We measure vintage effects by taking account of both variations in yearly production and a time series of weather data. The life-cycle price dynamics implied by the coefficients on age and its interactions with vintage quality are generally consistent with our model. High-quality vintages appreciate strongly while maturing for a few decades, but then prices stabilize until the wines become antiques, after which prices start rising again. For low-quality vintages, prices are almost flat over the first few years of the life cycle, but then rise in a near-linear fashion. The observation that prices of wines beyond maturity continue to rise with age points to the existence of a nonfinancial payoff from the ownership of relatively rare bottles of a well-known château. At the same time, our measurements of the financial under-performance of collectible wines compared with maturing wines suggest that the psychic return realized by wine collectors is probably small.

These results are robust to a variety of alternative specifications. Moreover, when examining the relation between vintage quality and the number of auction transactions over wines' life cycles, we find that trading volume falls much more quickly for low-quality vintages than for high-quality ones. This offers further evidence that wines from low-quality vintages rapidly become rare and can explain why they can have positive financial returns even as they become undrinkable.

To estimate the financial returns to wine investment over the long run, we apply a value-weighted arithmetic repeat-sales regression to all price pairs (i.e., combinations of prices for the same château and vintage year at different times) in our data. The resulting index picks up both the effects of aging on prices and the time series changes in the willingness to pay for wine. We find that inflation-adjusted wine values did not increase over the first quarter of the 20th century, experienced a boom and bust around the Second World War, and have risen substantially over the last half century. Overall, we find

an annualized real return of 5.3% between 1900 and 2012, but adjustment for the storage and insurance costs incurred by wine investors lowers the estimated return to 4.1%.

Including the benefit of cash dividends, equities have been a better investment than wine over the past century, and accounting for differences in transaction costs likely would lower the relative performance of wine investments even further, especially over short horizons. Yet returns on wine have exceeded those on government bonds and Treasury bills, as well as art and investment-quality stamps. As our model suggests, substantial positive correlation exists between the equity and wine markets. The strong price appreciation over the last half century also coincides with dramatic growth in the number of high net worth households worldwide with access to the market for Bordeaux wines. In recent years, for example, Chinese consumption of Bordeaux wines increased dramatically (Financial Times, 2014; Muhammad, Leister, McPhail, and Chen, 2014). To the extent that such globalization of the market was unforeseeable, historical returns could have been higher than anticipated ex ante.

Next, we report long-term evidence that is consistent with transitory bubbles in the price of collectibles such as wine. Periods that are identified in-sample as ones when financial markets were overvalued have a spillover impact on the prices of investments of passion, reinforcing these assets' mean-reverting behavior. Moreover, future returns on a collectible (e.g., wine) can be predicted to be lower after periods of outperformance relative to other collectibles (e.g., art and stamps).

We conclude by observing that the annualized return on First Growths that we report is best considered an upper bound on the long-term investment performance of wine more generally, as the relative popularity of the First Growths could have risen over our time frame. For the period 1972–2012, we find slightly lower returns for the sweet white wine Yquem and for a selection of ports.

The paper proceeds as follows. Section 2 provides an illustrative model of wine prices. Section 3 describes our data. Section 4 examines the impact of aging on prices, and Section 5 studies the long-term investment performance of wine. Section 6 concludes.

## 2. An illustrative model of wine prices

How can the price of a well-known wine be expected to change over time? How do returns differ between low-quality vintages that decline in quality quickly and high-quality ones that spend several decades maturing? And how can the impact of aging on prices be disentangled from time effects? In this section, we present a simple model that suggests answers to these questions. Crucially, our model accounts for both changes in a wine's consumption value and its attractiveness as a collectible over the life cycle.

Suppose that a representative collector-investor has wealth $W_0$ in period 0, with wealth growing at a constant rate $z$ so that $W_t = W_0 \times (1+z)^t$. The value of consuming a $j$-year-old bottle of wine at time $t$ can be defined as a function of the wine's drinkability $c_{i,j}$ and the investor's wealth, i.e., $C_{i,j,t} \equiv c_{i,j} \times W_t$, where $i$ represents the quality type of the vintage. The dependence of consumption value on wealth reflects the discretionary nature of luxury consumption (Aït-Sahalia, Parker, and Yogo, 2004). We assume two quality types. Wines of low-quality vintages, without aging potential, deteriorate over time so that $c_{L,j} = a^j \times c_{L,0}$ for each age $j > 0$, where $a < 1$ is the rate of deterioration. By contrast, wines of high-quality vintages improve monotonically by maturing until age $M$, i.e., $c_{H,j} = b^j \times c_{H,0}$ for each age $j \leq M$, with $b > 1$. After maturity, high-quality wines' drinkability stays constant, i.e., $c_{H,j} = c_{H,M}$ for each age $j > M$.[1]

Just like an artwork or a precious diamond, an unopened bottle of a famous château can be a source of enjoyment. We capture this nonfinancial utility with the parameter $d_{i,j}$ (with $d_{H,0} > d_{L,0}$), which grows with age, reflecting the higher enjoyment of owning older and rarer bottles. To the extent that nonfinancial dividends reflect the rarity of a wine, their growth rate is linked to the cumulative aggregate

[1] Ratings and tasting notes by experts reflect the differences in life cycles between vintages of different qualities. For example, in 2012, Robert Parker's website (http://www.erobertparker.com) labeled the 90-point 1997 vintage of Margaux "late" and the 88-point 1993 vintage "old," while the 98-point 1928 and the 100-point 1900 vintages were considered "mature."

consumption over the life cycle. However, even though we can expect to see a peak in consumption at maturity, when the value of drinking exceeds that of storing, we keep our model simple by assuming that the ownership dividend parameter increases with age at a constant rate $g$.[2]

The equivalent monetary value of the psychic ownership dividend for a bottle of quality type $i$ and age $j$ in period $t$ is defined as $D_{i,j,t} \equiv d_{i,j} \times W_t$. Our setup resembles the model in Goetzmann and Spiegel (1995) in which art values depend on collectors' wealth. Under the assumptions outlined above, the nonfinancial dividend grows at the rate $k \equiv (1+g)\times(1+z)-1$, which is assumed to be smaller than the appropriate discount rate $r$. In the model, tastes and the growth rate of wealth do not vary over time, and this discount rate can be set equal to the risk-free rate. However, if wealth is risky, the positive correlation between shocks to wealth and wine prices implies a required return close to that of the market portfolio. Uncertainty about future tastes and storage costs can further drive up the expected rate of return to wine investment, while uncertainty about future availability can depress it by increasing the convenience yield. The magnitude of the relevant discount rate is ultimately an empirical question.

In our setup, at each time $t$, the price of a $j$-year-old bottle of the low-quality type should be the maximum of two values, namely the value of immediate consumption and the present value of all future ownership dividends received conditional on never consuming:

$$P_{L,j,t} = \max\left(C_{L,j,t}\,,\ \frac{D_{L,j+1,t+1}}{r-k}\right). \qquad (1)$$

For the high-quality type, as long as the wine has not reached maturity, the price is the maximum of three measures: (1) the value of immediate consumption, (2) the present value of consumption at

[2] We assume that individuals deciding whether to drink or to store do not consider the marginal effect of their personal consumption on the attractiveness of the remaining bottles, though we note that Jovanovic (2013) provides an equilibrium model that endogenizes this decision. Various frictions can explain why not all bottles are consumed at maturity. For example, wine can be forgotten in large cellars, collectors with more wine than they can consume could be reluctant to sell, or a private-value component could make the utility from lifelong ownership exceed the consumption value, even at maturity (e.g., a collector wanting a complete collection of vintages).

maturity plus the present value of all ownership dividends received until consumption, and (3) the present value of infinite storage:

$$P_{H,j,t} = \max\left(C_{H,j,t}\,, \frac{C_{H,M,t+M-j}}{(1+r)^{M-j}} + \frac{D_{H,j+1,t+1}}{r-k} \times \left(1 - \left(\frac{1+k}{1+r}\right)^{M-j}\right),\ \frac{D_{H,j+1,t+1}}{r-k}\right) \text{ if } j < M. \qquad (2)$$

If the high-quality wine is at or beyond maturity, the price is the maximum of the value of consumption and the present value of all future ownership dividends:

$$P_{H,j,t} = \max\left(C_{H,j,t}\,,\ \frac{D_{H,j+1,t+1}}{r-k}\right) \text{ if } j \geq M. \qquad (3)$$

Fig. 1 shows an example of the resulting (log) price dynamics for a low-quality and a high-quality vintage of a famous château. We set *j* and *t* equal to zero in the first period. For the low-quality vintage in Panel A, the price decreases initially due to the decline in consumption value, until the value as a collectible (i.e., the present value of ownership dividends) exceeds the value of consumption. After this, the price grows at a constant rate *k*. In Panel B, we show the dynamics for a high-quality vintage that grows in drinkability for 40 years and does not change in consumption value thereafter. If the growth in consumption value prior to maturity exceeds the discount rate *r*, the price increases at a rate that approaches *r* as the wine nears maturity. After maturity, wine prices grow slowly with wealth until the present value of ownership dividends takes over, after which the price grows at a rate equal to *k*. Our simple model thus predicts very different price patterns for bad and good vintages. By comparing the two panels in Fig. 1, we can also see that the cross-sectional premium for vintage quality could be smaller for very old wines.

[Insert Figure 1 near here]

Eqs. (1) and (3) imply that the nonfinancial dividend yield *D*/*P* on collectible wines (i.e., those wines for which the price is determined by the value of lifelong storage) equals *r* minus *k*. This suggests that the psychic return on wines substantially beyond maturity can be approximated by their under-

performance relative to young high-quality wines that are still maturing. As such, our model closely relates to studies that attribute the under-performance of art relative to financial assets with the same risk profile to the "viewing pleasure" (Stein, 1977) or "conspicuous consumption utility dividend" (Mandel, 2009) associated with art ownership.

In Fig. 1, the price dynamics over age and over time are one and the same. Nevertheless, decomposing the returns into time and age effects is straightforward. Abstracting from aging-induced variation in quality (i.e., holding *j* constant), wine values grow with wealth over time, as the (future) consumption value and the (future) ownership dividends all rise at the constant rate *z*. More formally,

$$\frac{P_{i,j,t+1}}{P_{i,j,t}} = 1 + z. \tag{4}$$

By contrast, abstracting from the effects of time—and thus changes in wealth—on valuations (i.e., keeping *t* constant) delivers cross-sectional life-cycle patterns similar to those illustrated in Fig. 1, although the relative price differences between two consecutive age groups are lower than before:

$$\frac{P_{i,j+1,t}}{P_{i,j,t}} = \frac{P_{i,j+1,t+1}}{P_{i,j,t}} \times \frac{1}{1+z}. \tag{5}$$

Identifying the life-cycle price patterns of vintages of different qualities is the first goal of our empirical analysis. Afterward, we turn to estimating the total returns realized by wine investors since the beginning of the 20th century.

## 3. Data

We now introduce the wines that we study and describe how we collect price data from Christie's and Berry Bros. & Rudd. We also show some descriptive statistics.

### *3.1. Selection of wines*

We study transactions for five red Bordeaux wines: Haut-Brion, Lafite-Rothschild, Latour, Margaux, and Mouton-Rothschild. The Bordeaux region has long been among the world's leading wine areas, and the production of fine wines developed quickly after the introduction of bottles and corks in the late 17th century (Simpson, 2011). The important châteaus already had established reputations in the 18th century, a time when most other wine was still sold under the name of the shipper, not the grower. In 1855, wine brokers compiled a classification of wines for the Universal Exhibition of that year based on historical prices and labeled Haut-Brion, Lafite-Rothschild, Latour, and Margaux as the four red Premiers Crus or First Growths. By the end of the 19th century, this 1855 classification was well known. Mouton-Rothschild was classified as the first of the Second Growths but was widely believed to have the quality of a First Growth and traded at similar prices. The château was formally upgraded to the top category in 1973.

Not much time variation exists in the perceived quality of these wines. One reason for the relative stability in rankings is the importance of natural conditions, such as climate and soil, to the potential quality of a wine. Today, the Premiers Crus remain among the most highly appreciated and frequently traded wines in the world, and total annual production is about 70 thousand cases, or 840,000 bottles, on average, though production varies slightly across vintage years. The smallest producer among the First Growths is Haut-Brion, with eight to ten thousand cases per year. The largest ones are Lafite and Mouton, which typically produce 15 to 20 thousand cases per year (Leve, 2014).

*3.2. Data collection*

We compile a long-run price history for the five wines listed above, starting in 1899. Two other criteria guide the data collection. First, we focus on vintages since 1855. The compilation of the classification in that year makes it a natural starting point. The second half of the 19th century also saw the introduction of estate bottling for high-quality wines, along with their distinctive labels and corks. Second, we gather prices only for standard-size bottles, for a number of reasons: They make up a very large majority of all transactions historically, nonstandard bottles such as magnums are more likely to be valued for their uniqueness, and the aging process is affected by the size of the bottle, so excluding nonstandard bottle types simplifies the analysis.

We collect two types of historical price data: prices realized at auctions in the London sales rooms of Christie's (and W. & T. Restell, an auction house bought by Christie's in the 1960s) and retail list prices at Berry Bros. & Rudd, a London dealer of wines and spirits. At least until the First World War, "an important quantity" (Simpson, 2011) to "nearly all" (Penning-Rowsell, 1975) of the best Bordeaux wines were sold to British buyers. By considering only one auction house and one dealer over the long term, we mitigate concerns that our findings are affected by temporal changes in the nature of the price data. Moreover, these first-tier sellers have had a high reputation for a long time, which reduces worries about fakes or errors in item descriptions.

*3.3. Auction prices: Christie's*

Christie's is one of the world's two leading auction houses. Its first sale was held in December 1766 in London and consisted of "the property of a Noble Personage deceas'd." The auction included not only furniture, jewelry, and firearms, but also some "fine claret" (lots 30–34)—claret is the British name for red Bordeaux wine—and "fine old madeira" (lots 35–38). Christie's held its first session dedicated solely to wine in 1769. In the early decades, detailed descriptions of the bottles being

auctioned were often lacking. For a long time, wine was sold anonymously or under the name of the merchant who had imported it (Penning-Rowsell, 1972). It was not until 1788 that a Christie's catalogue (mis)named the Bordeaux châteaus "Lafete" and "Margeau" (Penning-Rowsell, 1973). Vintage quality became increasingly relevant only in the early 19th century, when Christie's catalogues regularly started to include information on château and vintage year. In 1941, the Christie's premises on King Street were destroyed by a firebomb, forcing the firm to move (Sheppard, 1960). There were occasional wine sales at the temporary offices, but these stopped altogether in 1945 and did not resume when Christie's returned to its original location in 1953. In 1966 the auction house renewed its wine business and acquired W. & T. Restell, the only other wine auctioneer in London at the time (Broadbent, 1985). Wine auctions remain an important part of Christie's activities in London today, with wine sales conducted on a near-monthly basis.

The long tradition of auctioning wines makes Christie's a unique source of long-term information. Nevertheless, building a database of wine prices is challenging due to the lack of a database that covers the firm's entire history and the fact that Christie's did not hold wine auctions continuously. We thus need to draw upon a number of different documents and sources.

For the period 1899–1971, we use data from archived catalogues containing the results of sales at Christie's (before 1945 and 1966–1971) and Restell (1941–1965). Fig. 2 shows an excerpt from an auction catalogue, annotated by the auctioneer, of a sale from 1935. For 1972–1979, we obtain price data at London auctions from the annual *Christie's Wine Review*, which is a publication that lists prices paid, generally at Christie's, over the previous calendar year. If more than a single lot of a particular wine was sold, the *Wine Review* reports the lowest and highest price and sometimes more price points. If no sale took place for a given château-vintage pair, the *Wine Review* repeats older price information. We eliminate these duplicates.

[Insert Figure 2 near here]

For the years 1980–1984 and 1988, we collect data from the *Christie's Vintage Wine Price Index* books, which succeeded the *Wine Review*. We obtain data from auctions at Christie's London for 1985–1987 and 1989–1998 from David Ashmore at Liquid Assets. Finally, we collect data on London wine sales over the period 1999–2012 from the Christie's website (http://www.christies.com). Throughout our analysis, we focus on homogeneous lots and do not consider mixed lots of wines from different châteaus or vintages. Over the period 1999–2012 (for which we have the most detailed data), a lot contained slightly less than ten bottles on average, with older (younger) vintages typically containing fewer (more) bottles per lot.[3]

We make three remarks about the auction data. First, the UK government has historically taxed sales of alcohol through excise duties. The payment of the duty (and value added tax), however, can be postponed by keeping the wine in bond. Duty is paid only when the bottle is removed from a bonded warehouse for delivery to a private address. Thereafter, the wine can be traded without additional taxes. We assume that all prices are duty-paid, and, thus, do not try to correct price levels for transactions in bond or for sales from foreign cellars. For high-end wines such as the ones considered here, excise duty is in any case relatively unimportant. At the end of 2012, the duty stood at 1.80 British pounds (GBP) per bottle.

Second, Christie's London introduced a buyer's premium in its wine auctions in the fall of 1986. This additional fee, payable by the winning bidder, was initially 10% of the hammer price of the lot and gradually increased to 15% by 2012. When necessary, we transform the observed prices so that they are inclusive of the premium. Because buyers take the premium into account as they bid, it can be considered a transaction cost imposed on the seller (Ashenfelter and Graddy, 2005; Marks, 2009).

[3] We can provide an indication of the volume of relevant sales at Christie's London as follows. In 2011, it sold 519 unmixed lots of standard-size bottles of First Growth wines. The lots represented 4,884 bottles and about 2.8 million British pounds (GBP) of sales (including buyer's premium). The worldwide total of all wine sales by the big auction houses amounted to about 250 million GBP in the same year (Bloomberg News, 2012).

Therefore, the evolution of hammer prices exclusive of buyer's premium would underestimate the growth in the willingness to pay for wine.

Third, London's other major auction house, Sotheby's, started organizing wine sales in the 1970s, and we use its prices to validate our long-term database. We already know from Ashenfelter (1989) that in the mid-1980s total buyer's prices were similar at Christie's London and Sotheby's London. Here we examine London wine auction results for both Christie's and Sotheby's over a longer time frame, using the 1985–1998 data source described earlier. Keeping the combination of château, vintage, and transaction year fixed, Sotheby's mean prices are a statistically insignificant 0.9% below Christie's. We also collect recent prices from the Sotheby's website (http://www.sothebys.com) and examine the 12 château-vintage combinations that traded at both houses in 1985 and in 2012. The annualized price appreciation differs between the two houses by less than 0.3%. We are reassured that our findings are not sensitive to the choice of auctioneer.

*3.4. Dealer prices: Berry Bros. & Rudd*

In 1698, a small grocery store was founded at 3 St. James's Street in London, not far from where Christie's is located today. By the early 19th century, the shop had come into the hands of George Berry, son of a wine merchant, who transformed it into a wine business, and the Berry family has been active in the company ever since. Price lists show that French and German wines, spirits (e.g., brandy, whiskey, gin), and fortified wines (e.g., port, sherry, madeira) were the backbone of the business in the early 1900s. Hugh Rudd, also from a family of wine merchants, joined the company in 1914. Today, BBR also has an online wine shop and brokering service.

As is the case for Christie's, the history of BBR offers a long-run perspective on the evolution of wine prices. Since the early 20th century, BBR has generally issued price lists in the spring and fall of each year, though it recently reduced the frequency to once per year. For the period 1905–1978, we can

collect data on the five Bordeaux wines that we study from a set of 11 bound volumes of price lists. We use loose copies of the relevant price lists for a number of years not included in the bound volumes and for the period since 1978. All documents were consulted at the London headquarters of BBR. Fig. 3 reproduces two pages from the May 1909 price list.

[Insert Figure 3 near here]

Each list typically includes from a handful to a few dozen prices useful for our study. During the late 1980s and the 1990s, the lists do not always include prices for relevant wines, which are mentioned to be available on request. In the early 2000s, BBR introduced separate Blue Lists with prices for "the finest reserve wines and wines for laying down". Prices from these alternative lists also enter our database. In recent years, the BBR website (http://www.bbr.com) has largely assumed the role once played by the printed price lists. We, therefore, complete our database with November 2012 prices taken from the BBR website.

A few further comments on the dealer price data are in order. From the 1920s until the 1960s, the lists often include both credit and cash prices, and we work with the latter. Our prices are also duty-paid and inclusive of value added tax (which we add when necessary) and thus reflect the total cost to domestic buyers who take physical possession of the wine. Whenever possible, we use prices per bottle instead of per case. We also ignore quantity discounts because we lack detailed information on them for each period, and we do not take into account other discounts such as for imperfect quality or seasonal promotions offered by BBR. For these reasons, prices in the retail lists are likely an upper bound on the true underlying values, just like catalogue prices in other collectibles markets. At the same time, we are mainly interested in quantifying the trends in prices, and a systematic upward bias in all prices would not affect these trends.

*3.5. Construction of final database and descriptive statistics*

In total, we hand-collect 36,271 prices from the various Christie's and BBR sources. If we know that an auction took place or that a dealer issued a price list in the first half of the year, we assign the accompanying price points to the previous year-end. In all other cases, we date the price to the end of the year. Next, so as not to overweigh certain periods or transaction types, we average prices per bottle by quartet of year-end (e.g., end-2007), château (e.g., Latour), vintage (e.g., 1982), and transaction type (dealer or auction). Our final database contains price information for standard-size bottles on 9,492 such combinations (our units of observation from now on) since end-1899.[4]

Table 1 presents some descriptive statistics for our data set. Panel A of Table 1 shows the number of observations per transaction type and per château for each decade since the 1900s (where 1899 is added to the first period). The growth of the database in the 1970s reflects the increasing availability of auction sources. Panel B gives more information on the distribution of the averaged prices in GBP for each decade, in nominal and real (year 1899) terms. Until the early 20th century, no wine sold for more than one pound per standard-size bottle. For the most recent years (2010–2012), the average price level per bottle is 758.46 GBP, with prices ranging from 80.50 to 8,510 GBP. We observe much stronger increases in both nominal and deflated prices in the second half of the 20th century than in the first half.

[Insert Table 1 near here]

[4] If we assume that all wines could be sold as of the first year after the vintage (which is not always the case), there would be 114,570 combinations of year-end (1899–2012), château, vintage year (1855–2011), and transaction type for which prices could in theory be observed. Our database thus covers 8.3% of the population of (potential) values.

## 4. Aging and prices

In Section 4, we examine the effect of aging on the price of wines of different quality, by estimating hedonic regressions. We also discuss how auction trading volume changes over the life cycle.

### *4.1. Methodology*

Hedonic models relate transaction prices to their value-determining characteristics (Rosen, 1974) and are commonly used to study price formation in markets for infrequently traded assets such as real estate (e.g., Campbell, Giglio, and Pathak, 2011) and art (e.g., Renneboog and Spaenjers, 2013). Ashenfelter, Ashmore, and Lalonde (1995), Di Vittorio and Ginsburgh (1996), and Combris, Lecocq, and Visser (1997) were among the first to estimate hedonic regressions for Bordeaux wines.

Determinants of price levels that we would like to control for in our analysis of age effects (on different quality levels) are the identity of the château, the transaction type, vintage attributes, and the year of sale. Vintage attributes are often summarized by the year in which the grapes were harvested. However, vintage-year dummy variables are unsuitable for our regressions because they would introduce multicollinearity with age and year of sale. The superficially appealing approach of including dummy variables for all three dimensions must therefore be ruled out.[5] Instead, we estimate vintage attributes in a more direct way. We assume that the vintage attributes that impact prices are the annual levels of production (as a larger supply can be expected to relate to lower prices) and each year's weather quality.

With respect to production, we use an anonymous First Growth château's historical yields (measured in hectoliters per hectare) from Chevet, Lecocq, and Visser (2011). Next, we use information on the weather in each vintage year as a proxy for quality. Ashenfelter, Ashmore, and Lalonde (1995)

[5] A similar problem is faced by studies that aim to disentangle age, cohort, and year effects in household portfolio choice (e.g., Ameriks and Zeldes, 2004; Malmendier and Nagel, 2011). Our work also relates to research that disentangles age from time effects in values of durable corporate assets such as aircraft (e.g., Staunton, 1992).

and Ashenfelter (2008) show how weather data predict the quality and prices of Bordeaux wines. Using daily data from a weather station in Bordeaux (Météo Climat, 2012), we measure the average temperature between April and August (the growing season) and total rainfall in August and September (the harvest season) for each vintage year between 1873 and 2011.[6] We then sort all vintages into deciles according to both measures and assign a score of one to ten to each vintage year for each measure, where higher temperatures and less rainfall are associated with higher scores. Our weather quality variable sums the two scores. It is thus close to 20 for a warm growing and dry harvest season.

Advances in technology over our sample period could have made the weather a less important determinant of vintage quality. Later in this section, we report the robustness of our results to using an alternative price-based quality measure. We do not use vintage charts or expert ratings as quality measures for two reasons. First, they are not exogenous, as today's scores are typically determined by tastings from recent years and are susceptible to updating over time. Resolution of uncertainty about quality could thus correlate with both returns and changes in scores (e.g., Jones and Storchmann, 2001). Second, no rating system covers all vintage years considered here. For example, Robert Parker Online has only very selective coverage for the first half of our time period, with better years more heavily represented. Nonetheless, the correlations (across all in-sample combinations of château and vintage year) of our weather quality variable with either end-2012 Parker scores or red Bordeaux vintage chart scores from an international retailer of rare wines (SoDivin, 2012) are relatively high (0.36 and 0.63, respectively) and statistically significant at the 0.01 level.

Formally, our regression model is

$$\ln\left(P_{i,j,l,t}\right) = \alpha_i + \alpha_l + \alpha_t + \varphi Y_j + \psi W_j + \boldsymbol{\beta}'\boldsymbol{X}_{j,t} + \boldsymbol{\gamma}'\left(W_j \times \boldsymbol{X}_{j,t}\right) + \varepsilon_{i,j,l,t}\,, \qquad (6)$$

[6] Weather data for Bordeaux are available since 1880. For 1873–1879 and later years with missing data (e.g., 1915–1920 and 1940–1945), we impute values using linear regression models relating monthly data on temperature and rainfall in Bordeaux to data for Paris and Marseille (and Nantes, when possible) and month fixed effects over the period 1880–2011.

where $P_{i,j,l,t}$ is the price of a wine from château $i$ and vintage year $j$ at sale location $l$ (i.e., the transaction type: dealer or auction house) in year $t$. The different $\alpha$ denote fixed effects, $Y_j$ measures the production yield in year $j$, $W_j$ picks up the quality of the weather in the same year, and $\boldsymbol{X}$ is a polynomial age function. In our baseline model, $\boldsymbol{X}$ is a third-degree polynomial. We include interactions of our newly created weather quality variable with the age polynomial to test our hypothesis that the relation between age and price levels depends crucially on the quality of the vintage.

*4.2. Results*

We estimate Eq. (6) using ordinary least squares with the price level in real GBP as the dependent variable and cluster standard errors by sale year. The sixth column in Table 2 summarizes the results. The *R*-squared statistic is 0.74, which is higher than the explanatory power of the models in the first five columns of Table 2 that combine subsets of variables in different ways.

[Insert Table 2 near here]

Before we study the effect of aging on prices, we review the results for the other variables included in our benchmark hedonic model. The coefficient on the transaction type dummy indicates that dealer prices exceed auction prices on average. Clients could value the condition (and certainty about authenticity and provenance) of bottles sold by BBR, but the list prices should in any case be considered an upper bound on true transaction prices. Next, Mouton-Rothschild carries a premium relative to the other four châteaus in our sample. Haut-Brion, which is omitted from the regression due to multicollinearity, is the least expensive, ceteris paribus. The results also indicate strongly significant relations between our proxies for vintage effects and prices, with the coefficients relating lower production and better weather to higher prices as expected. Finally, the year-of-sale dummies control for changes in wine values over time, independent of aging effects. We provide a detailed description of historical price trends, focusing on the total net returns to investors, in Section 5.

We now turn to the relation between age and price levels. An *F*-test shows that the coefficients on the interaction terms between age and quality are jointly statistically significant. This suggests that wines of low- and high-quality vintages exhibit different life-cycle patterns. Fig. 4 shows the life-cycle price patterns implied by the coefficients on the weather quality variable, the age polynomial, and the interaction terms, for otherwise identical wines of the lowest and highest weather quality categories. We rescale the predicted price of the lowest-quality wine at age zero to unity and show results up to an age of one hundred years. (Less than 3% of our observations are for wines older than a century.) Fig. 4 also shows the confidence intervals around the predicted price levels.

[Insert Figure 4 near here]

For the lowest-quality vintages, prices increase little over the first few years of the life cycle. The geometric average price appreciation over the first two decades implied by our results is only 0.6%. Afterward, prices rise faster and in a near-linear fashion. In contrast, the highest-quality wines appreciate strongly while they are maturing after the vintage. We estimate a geometric average price appreciation of 4.0% over the first 20 years. Prices stabilize once high-quality wines fully mature, and their increase in value between age 40 and 80 is very limited. As the wines become antiques, we begin to observe new price increases. The first row of Table 3 summarizes the cross-sectional price changes over the life cycle for the worst-quality type (until an age of 60 years) and the best-quality wines as predicted by our regression results.

[Insert Table 3 near here]

The patterns in Fig. 4 are generally in line with the model presented in Section 2 and illustrated in Fig. 1. The highest returns are realized on young high-quality wines that are maturing. Given that we are using an exogenous measure of quality, this result is not driven by resolution of uncertainty about the wine's quality over its life cycle. The observation that the prices of wines substantially beyond their optimal consumption point—low-quality wines older than a few decades or high-quality wines

approaching a century—go up with age is consistent with the theorized existence of a growing nonfinancial payoff to owning such wines. Finally, given that consumption quality slowly becomes irrelevant for all wines, it is not surprising that the relative difference in price levels between high-quality and low-quality vintages is smaller for very old wines than for young wines.

According to our model, the return difference between high-quality wines approaching maturity and wines long beyond maturity (i.e., collectible wines whose prices are determined by the nonfinancial dividends they provide) should offer an indication of the psychic return to holding the latter type of wines. The results in Table 3 suggest that the nonfinancial return realized by collectors is probably relatively small. For example, the financial outperformance of pre-maturity high-quality vintages (ages zero to 20 years) relative to post-maturity low-quality vintages (ages 40 to 60 years) is only about 1.3% per year. Under our model's assumptions, this estimate would imply that a collectible wine worth 100 GBP provides a nonfinancial dividend of 1.3 GBP to its owner over the course of a year.

*4.3. Robustness checks*

We now check the sensitivity of our results to a number of robustness checks. First, we split the sample in the period before 1980 and the years since 1980, which gives two subsamples with a nearly equal number of observations. Second, we repeat our hedonic regression model using auction transactions only, to mitigate concerns that the documented patterns are due to risk sharing between wine producers and dealers, leading to overpriced bad vintages and underpriced good ones. Third, we replace the third-order age polynomial with a fourth-order polynomial, allowing for more flexibility in the estimation of the age effects. Fourth, we construct an expanded measure of weather quality. Ashenfelter (2008) shows that, in addition to temperature in the growing season and the rainfall during the harvest season, rainfall during the winter preceding the vintage can affect wine quality to some extent. All else equal, more winter rain is associated with slightly better wines in the next vintage. We therefore create a score from one to ten based on the decile to which each vintage year belongs when

sorted on cumulative rainfall in the period from October to March and add half of this score to the previously constructed weather quality variable. Fifth, we construct an entirely new exogenous measure of vintage quality as follows. Bordeaux producers have historically sold forward contracts on wine not yet bottled through the system of en primeur transactions. Short-term changes in the so-called opening price set by the château reflect variation in vintage quality (Ali and Nauges, 2007). We use data from Dovaz (1999) on the opening price of Latour (1855−1997) and create a relative vintage quality measure by dividing the opening price in a year by the average opening price in the two surrounding years. We exclude vintages with multi-year contracts.

Table 3 shows the predicted geometric average price appreciation over different segments of the life cycle of the lowest-quality and highest-quality vintages for these alternative specifications based on the coefficients for the age and age-quality variables. It also compares the results with our benchmark model. In each specification the general patterns are similar to the benchmark results: Maturing wines show the highest returns to aging, but wines long beyond maturity also increase in value with age.[7]

*4.4. Vintage quality and trading over the life cycle*

We argue that wines from poorer vintages lose whatever consumption value they have more quickly. As they are more likely to be consumed when still young, we should expect that the trading volume of these wines goes down more rapidly than that of better vintages. We test this hypothesis using data on the number of sold auction lots per combination of vintage year and sale year between 1985 and 2012 (for which we have volume data at Christie's) in our database. We compute the average annual auction volume for each age both for relatively low-quality wines (weather quality < 8) and for

[7] Results are also similar when extending the benchmark model with an interaction of the dealer dummy and a linear time trend (to account for the possibility that the dealer premium has changed over time) or when including pre-1973 and post-1973 Mouton dummies (to allow for a potential change in demand following the upgrade to First Growth). We also check whether a positive relation exists between the reputation of the artist designing the Mouton label and transaction prices, but we do not find evidence of such an effect.

relatively high-quality wines (weather quality > 12). We then average over five-year age groups (starting with ages 5–9, because wines rarely sell at a younger age). Fig. 5 shows that the result is in line with our expectations. Wines from worse vintages become rarities more quickly—after two decades or so—which is consistent with the price patterns reported earlier. These results also indicate that the high returns to young high-quality wines are not driven by decreases in availability. Wines from high-quality vintages remain in relatively high supply for about four decades, corresponding to the time it takes to fully mature.

[Insert Figure 5 near here]

## 5. The long-term investment performance of wine

We now evaluate wine's investment performance over the 113 years spanned by our sample, a performance that reflects changes in market conditions in addition to the price increases related to aging discussed in Section 4. We also compare wine with other assets, examine the relation between wealth creation and wine prices, and study whether wine returns are predictable. Finally, we explore the impact of success bias on our results.

### *5.1. Methodology*

To build a returns index, we apply a repeat-sales regression to the 8,582 price pairs in our database for which the château and vintage (and transaction type) are identical.[8] The standard repeat-sales regression (e.g., Bailey, Muth, and Nourse, 1963) estimates the return on an underlying portfolio of assets by relating the log returns implied by the individual price pairs to the periods over which the assets are held. An advantage of the methodology is that it explicitly controls for the uniqueness of each

[8] One example of a price pair is the following: The average transaction price of a bottle of Margaux of vintage year 1945 at auction was 133.51 GBP in 1985 and 168.48 GBP in 1986. For many château-vintage combinations, we observe prices for long series of consecutive years.

combination of château and vintage year. There is thus no need to estimate the average premia associated with, for example, different categories of weather quality. However, an issue with the standard repeat-sales model is that, just like the log-linear hedonic model of which it is a special case, it estimates an equal-weighted index based on the geometric (instead of arithmetic) average of prices in each period. As this is undesirable, we follow the variant proposed by Shiller (1991), which works with absolute prices instead of log returns. The result is a value-weighted arithmetic repeat-sales index that more accurately tracks the investment performance of wines held by collectors.

*5.2. Results*

The line plot in Fig. 6 shows the price index, in real GBP, that we obtain with the arithmetic repeat-sales technique. The index is set to unity at the start of 1900. We geometrically interpolate the index values for the years 1912, 1916, 1917, and 1947, for which we have no transactions that enter the estimation. The index shows that, despite the positive average effect of aging on the consumption value and attractiveness of wines, wine prices did not increase in real terms over the first quarter of the 20th century. Fig. 6 also shows that the value of wines boomed during the Second World War. Prices increased by more than 600% between 1940 and 1945. Many factors probably played a role: The war upset the trade in high-end French wines, with the port of Bordeaux and many châteaus occupied by Nazi Germany (Kladstrup and Kladstrup, 2001); the UK government prohibited sales of wines and spirits by unlicensed auction houses; Christie's had to limit its sales activities after its main offices were bombed; and many wine bottles were sold through Red Cross charity auctions that are not included in our data but could have pushed up price levels. The boom was followed by sharp decreases in wine prices in the years after the end of the war. In the second half of our time frame, wine prices grew strongly, although the increases were punctuated by declines in real price levels of more than 20% in 1973–1975, 1980, 1990–1992, 2003, and 2011–2012. Over the complete 1900–2012 period, we find a geometric average annual real return of 5.3%. For completeness, the bars in Fig. 6 show the nominal

return for each year on the left-hand axis. The geometric average annual nominal return over our time frame is 9.4%.

[Insert Figure 6 near here]

The index values are relatively precisely estimated. The standard errors on the last index values imply a 95% confidence interval around the annualized return estimate that is about 1 percentage point wide. Moreover, for the time frames that overlap with earlier research on wine returns, i.e., 1969–1976 (Jaeger, 1981), 1986–1996 (Burton and Jacobsen, 2001), and 1996–2009 (Masset and Weisskopf, 2010), the estimated trends are broadly in line with those reported by others.[9]

*5.3. Accounting for storage and insurance costs*

The condition of a bottle of wine is determined by factors such as temperature and humidity. A poor storage environment can cause bottles to start leaking or evaporating, wines to become oxidized, and labels and packaging to experience damage. Such wines are less likely to be included in our database. Auction houses would nowadays typically not even sell bottles that have a questionable provenance, even if they appear to be in a decent condition. The reported returns in Section 5.2 therefore have been realized only by investors who stored their wines properly. Today, storing wine bottles does not need to cost much. Robinson (2010) mentions a cost of 10 to 20 GBP per dozen bottles per annum at professional storage providers. However, relative to the average price of wine, storage was more expensive before the increases in wine values of the last decades. For example, the BBR price list of March 1940 shows that a case of wine could then be stored at a price of 1.6 shilling, or 0.075 GBP, per year—a cost equivalent to 0.94% of the average end-1939 price for a dozen bottles. Repeating this exercise in 1950, 1960, 1970, 1980, 1990, and 2000 delivers estimates of 0.83%, 0.88%, 0.39%, 0.13%,

[9] As an additional robustness check we run a hedonic regression model with dummies for the different châteaus, transaction types, and vintage years as controls. The resulting return series is highly correlated (0.84) with the one presented here, and the geometric average annual return estimate is similar (4.6%).

0.24%, and 0.23% respectively. We use these estimates of transaction costs at the start of each decade to correct our annual returns. We use the 1940 cost estimate for the years prior to 1940, and for 2010–2012 we use the 2000 estimate.

In addition, the reported returns clearly include only those bottles that were unaffected by or insured against fire, flood, accidental breakage, theft, and other hazards. Wine storage contracts often do not include insurance or do not insure against all risks at full market value. Meltzer (2005) notes that, although the exact policy and cost is a function of the insurer, premiums are fairly uniform. A typical wine insurance contract costs close to 0.5% of the market value of the collection per year.

In Fig. 7, we show our deflated price index after accounting for these storage and insurance expenses. (The observation that storage and insurance costs are low relative to historical returns suggests that returns are not driven by a negative convenience yield.) We estimate an annualized real return, net of storage and insurance costs, of 4.1% between 1900 and 2012. This corresponds to an annualized nominal return of 8.2%.

[Insert Figure 7 near here]

*5.4. Comparison with other assets*

Fig. 7 also shows returns to a number of other financial assets and collectibles. Data on British equities, government bonds, and bills are from Dimson, Marsh, and Staunton (2013). For the art market we use an index for Great Britain from Goetzmann, Renneboog, and Spaenjers (2011), updated until end-2012 using data from Artprice (2013). Data for British stamp prices are from Dimson and Spaenjers (2011), updated using returns on the Stanley Gibbons GB30 index. Table 4 shows summary statistics for the different distributions of returns in both nominal and real terms.

[Insert Table 4 near here]

Annualized real returns over the period 1900–2012 are 5.2%, 2.4%, and 2.8% for equities, art, and stamps, respectively. Wine has thus under-performed equities over this time, although the difference in cumulative appreciation has narrowed since the start of the 21st century. When comparing average returns on wine with those on financial assets, however, it is important to bear in mind that transaction costs could lower the relative performance of wine investments more than trading costs depress the returns on investment in financial assets, especially over short holding periods. For example, the buyer's premium at Christie's London was 15% at the end of 2012, while the commission paid by the seller can be as large as 10%. So a seller could receive only about 75% of the amount that the winning bidder pays out. These estimates could still underestimate true costs, as purchasers and sellers of wine can incur expenses related to transportation, handling, and administration when moving the wine from one storage facility to another.

At the same time, Table 4 and Fig. 7 show that wine has outperformed not only government bonds, but also art and stamps, even when ignoring the insurance and storage costs associated with investments in those types of collectibles. This might not be surprising as a majority of the wines that trade are relatively young and high-quality, which give the highest financial returns. Moreover, even as a collectible, age can be a more important determinant for the attractiveness of wine than for art or stamps, making wine an asset with higher capital gains but a lower nonfinancial dividend yield.[10]

[10] Wine also provides British investors with an unusual tax advantage, as it is regarded for tax purposes as a wasting asset. Wasting assets have a predictable life span of no more than 50 years and can be sold without liability to capital gains tax (HMRC, 1999). (Port and other fortified wines are not considered as wasting assets, as they have a very long storage life.) Even if the investor sells a bottle of wine following the 50-year cutoff, it could still be tax-free if the price does not exceed 6,000 GBP. These advantages were unforeseen before 1965 (when the capital gains tax was introduced) and do not apply to the other assets depicted in Fig. 7. They could therefore have provided a modest boost to returns.

Finally, Table 4 shows that our wine index is volatile, although the standard deviation falls to a level similar to equities when we remove the boom and bust caused by the Second World War.[11]

*5.5. Wealth and wine prices*

In the model presented in Section 2, time effects in wine prices reflect growth in the wealth of wine investors, as drinking and collecting wine are both forms of discretionary luxury consumption. To examine whether wine prices respond to wealth shocks, we run a regression (without constant) of the real wine returns (before costs) against the returns on equities, which results in a market model beta of 0.44. The (aggregated) slope coefficient increases to 0.73 when taking into account non-synchronicity in returns by adding a lagged and a leading equity return to the regression, following Dimson (1979).[12] These results point to a strong relation between the creation of financial wealth and wine prices.[13]

Our simple representative-collector model does not consider changes in the population and attributes of wine buyers. In practice, however, economic globalization, coupled with strong increases in wealth outside the UK, probably contributed to the elevated returns exhibited by our index since the 1960s. As high-end wines are in fixed supply, in wide demand, and easily transportable, growth in the number of high-income households with access to the market can raise prices even if each individual's reservation price does not change (Gyourko, Mayer, and Sinai, 2013). The crowding out of English middle-class families and Oxbridge colleges in the market for high-end Bordeaux wines by new and

[11] The standard deviation of the real returns on wine falls to 20.3% when we exclude the years from 1941 to 1948, which is close to the 19.8% observed for equities. Even so, standard deviations can still overestimate the true volatility of returns to holding wine before the 1970s due to the relatively low number of observations upon which our return estimates are based for the first half of our sample (Bocart and Hafner, 2015). However, the use of dealer price lists and the aggregation of prices over one-year periods can lead to artificial smoothing in the return series.

[12] Non-synchronicity between equity returns and wine returns can arise for several reasons. For example, while equity returns can be measured exactly at year-end, wine returns are estimated based on (infrequently observed) auction and dealer prices both before and after the turn of the year. Excluding the period 1941–1948, the aggregated market model beta equals 0.57.

[13] In additional unreported analysis, we find a weak positive correlation of wine returns with GDP growth and a weak negative correlation with changes in the USD/GBP exchange rate.

wealthy groups of wine enthusiasts from around the world is consistent with this superstar mechanism.

The globalization of the wine market—not only at the high end—becomes clear from long-term trade statistics compiled by Anderson and Nelgen (2011). While worldwide beverage wine consumption has not changed much between 1961–1964 and 2005–2009 (around 22,500 megaliters per year), the volume of international trade has more than tripled over the same period (growing from 2,602 to 8,375 megaliters per year). Moreover, the share of imports in Europe within worldwide imports has dropped from 90% to 75% (even as exports to the UK have risen strongly).

In recent years, the growth in China's demand has been especially striking. In US dollar terms, wine imports into China grew at an annualized rate of 61.5% in the 1990s and 37.1% in the 2000s, making it the country with the strongest import growth rate over this time frame. China (including Hong Kong) became the world's largest importer of Bordeaux wines in 2010 (Anson, 2011), claiming a position historically held by the UK. In 2012, Christie's sold 909 (unmixed) lots of First Growth Bordeaux in Hong Kong, about 80% more than in London.[14] Such fundamental changes in Chinese demand patterns were almost certainly unforeseen (Muhammad, Leister, McPhail, and Chen, 2014). Historical returns can, therefore, have been higher than wine buyers anticipated ex ante—and also higher than should be expected going forward.

*5.6. Predictability of the returns to wine and other collectibles*

It seems plausible that collectibles such as wine exhibit bubble-like behavior, especially given the difficulties with pinning down fundamental values and the impossibility of short selling.[15] We explore the power of two simple measures, both based on asset prices, that can be used to predict five-year real

[14] Moreover, a hedonic regression on the transaction data for the same year shows that prices were about 10% higher in Hong Kong than in London (controlling for château and vintage effects). We thank Roman Kräussl for providing us with the Hong Kong auction data.

[15] LeRoy (2004) argues that both rational and irrational bubbles can exist on collectibles. Renneboog and Spaenjers (2013) and Pénasse, Renneboog, and Spaenjers (2014) show a relation between sentiment measures and prices in the art market.

returns, starting at year-end *t*, on wine, art, and stamps. Our first variable is the difference between the annualized return, measured over the five years prior to *t*, on a collectible (e.g., wine) and the average annualized return, measured over the same period, on the other two collectibles considered (e.g., art and stamps). If similar macroeconomic fundamentals, such as wealth creation and globalization, drive long-term price trends for all collectibles, then deviations from the average price path can provide evidence of a temporary fad. The second return predictor that we propose is an equity valuation ratio at time *t*. Given the tight relation between wealth and luxury consumption demand, overvaluation in financial markets could spill over into collectibles markets. In this paper, we use data on ten-year cyclically adjusted price-dividend ratios for the UK equity market from Dimson, Marsh, and Staunton (2013), which we de-trend over the sample period.

Panel A of Table 5 shows the in-sample correlations of the five-year returns to wine, art, and stamps with these two prior measures. We see negative correlations between –0.13 and –0.28. The first column of Panel B shows the result of a regression of collectible returns against the two predictors and collectible fixed effects. Because our regressions are based on overlapping observations, we report standard errors that are adjusted using Newey-West (with four lags). We see a strongly negative relation between our measures of overvaluation and future real returns. In the second and third columns, we split the sample period in half. In both subperiods, we find evidence of a negative correlation between recent relative performance and future returns. Moreover, while the coefficients on the equity valuation variables lose statistical significance at traditional levels (having *p*-values of 0.10 and 0.15), they are of the same order of magnitude as before.

[Insert Table 5 near here]

The results in Table 5 show that there exists some in-sample predictability of returns in collectibles markets. We leave it to future research to test out-of-sample predictability and to evaluate the potential profitability of trading strategies based on forecasts generated by price prediction models.

*5.7. Exploring the impact of success bias*

In this paper, we estimate the returns to the best red Bordeaux wines. Although these wines were well known and highly appreciated before the start of our time frame, a few other types of wine have historically been popular as well, even for the purpose of investment. For example, the *Christie's Wine Review 1972* noted that vintage port "has been *the* wine, par excellence, for the English [to] lay down—to invest in—and to drink." So if today's professionally managed wine portfolios invest over 80% of their funds in only eight red Bordeaux wines (Miles, 2009), it is likely that such an overwhelming focus on claret would have seemed unnatural to wine buyers a century, or even a few decades, ago. The reported returns on red First Growths should therefore probably be considered an upper bound on the long-term investment performance of wine more generally.

To get a better sense of the importance of this success bias, we perform two checks. First, for the years since end-1971, we were able to collect auction and dealer prices for Château d'Yquem, a Superior First Growth sweet white wine from Bordeaux, from the same sources as before. The data allow us to estimate 40 years of returns for this very different type of wine. A value-weighted arithmetic repeat-sales regression generates a geometric average return estimate of 4.8% between start-1972 and end-2012. This compares with 6.9% for the (red) wine price index presented earlier. Second, for each vintage port that was included in the 1972 *Wine Review*, we check whether we can find a transaction at Christie's London during the last three years of our time frame (2010–2012). We find five such instances: Croft 1945, Fonseca 1966, Warre 1955, and Taylor 1945 and 1963. The geometric average real returns implied by these price pairs range from 4.6% to 7.2%.

This suggests that the returns on other types of wine have been somewhat lower over the last few decades. Yet the differences are not dramatically large, and even d'Yquem has performed as well as government bonds over the last four decades (net of storage and insurance costs).

## 6. Conclusion

We first study how financial returns change over a wine's life cycle. A simple model of wine prices delivers predictions of how prices can be expected to change differently over the life cycle for low-quality and high-quality vintages. We then construct a database containing prices for 9,492 combinations of Bordeaux First Growth château, vintage year, year-end, and transaction type since end-1899, and we use these data to estimate age effects in wine prices. We parameterize vintage effects by using measures of annual production yield and weather quality. The life-cycle price patterns implied by the results are generally consistent with our model. High-quality wines appreciate strongly while they mature, but their prices stabilize after a few decades. Prices start rising again when the wines become antiques. By contrast, wines from low-quality vintages appreciate little during the first years after bottling but show a near-linear price appreciation starting around the time that trading volume dries up. Our results are consistent with the existence of a nonfinancial payoff—increasing with age—from the ownership of rare wine, even if the nonfinancial return is probably small relative to the capital gains realized by wine collectors.

Next, we estimate the long-term returns in the market for high-end wines. We apply a value-weighted arithmetic repeat-sales regression to the price pairs in our database to construct a price index in real GBP terms. We find a geometric average real return of 5.3% between 1900 and 2012. Taking into account storage and insurance costs lowers this estimate to 4.1%. Over our time frame, wine has been outperformed by equities, and transaction costs could further reduce the relative attractiveness of wine. However, the performance of wine has been better than that of art and stamps. Moreover, we find evidence of positive correlation between wealth creation and wine prices. Consistent with this observation, we show that periods that are identified in-sample as ones when financial markets were overvalued have a spillover impact on the prices of collectibles. Future returns on a collectible (e.g., wine) also are predicted to be lower when the recent performance compared with other collectibles (e.g.,

art and stamps) has been better. Finally, the historical returns on wine, impacted by the strong growth in the number of high net worth individuals worldwide, might have been higher than anticipated ex ante.

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**Table 1**

Descriptive statistics

The table shows descriptive statistics for our database. Historical prices of the five red Bordeaux First Growths were collected from Christie's London (an auction house) and Berry Bros. & Rudd (a dealer). The unit of observation is the average price (in British pounds) per bottle per quartet of year-end, château, vintage, and transaction type. Panel A shows the number of observations per transaction type and per château for each decade since end-1899. Panel B shows summary statistics for the distributions of nominal and real prices (deflated to end-1899 prices) for each decade since end-1899. Inflation data are from Dimson, Marsh, and Staunton (2013).

*Panel A: Number of observations per transaction type and per château*

| Period | Transaction type | | Château | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | Auction | Dealer | Haut-Brion | Lafite | Latour | Margaux | Mouton | |
| 1899–1909 | 179 | 47 | 12 | 88 | 36 | 48 | 42 | 226 |
| 1910–1919 | 37 | 69 | 10 | 40 | 10 | 24 | 22 | 106 |
| 1920–1929 | 54 | 86 | 9 | 52 | 25 | 45 | 9 | 140 |
| 1930–1939 | 62 | 141 | 24 | 38 | 47 | 74 | 20 | 203 |
| 1940–1949 | 88 | 15 | 18 | 24 | 21 | 24 | 16 | 103 |
| 1950–1959 | 47 | 131 | 24 | 60 | 42 | 36 | 16 | 178 |
| 1960–1969 | 163 | 96 | 47 | 44 | 91 | 45 | 32 | 259 |
| 1970–1979 | 1,568 | 89 | 251 | 383 | 442 | 304 | 277 | 1,657 |
| 1980–1989 | 1,839 | 96 | 341 | 436 | 419 | 344 | 395 | 1,935 |
| 1990–1999 | 1,956 | 198 | 360 | 477 | 452 | 361 | 504 | 2,154 |
| 2000–2009 | 1,830 | 254 | 320 | 448 | 475 | 347 | 494 | 2,084 |
| 2010–2012 | 409 | 38 | 63 | 125 | 91 | 76 | 92 | 447 |
| 1899–2012 | 8,232 | 1,260 | 1,479 | 2,215 | 2,151 | 1,728 | 1,919 | 9,492 |

*Panel B: Summary statistics of prices per bottle (in British pounds)*

| | Nominal | | | | Real | | | |
|---|---|---|---|---|---|---|---|---|
| Period | Mean | Standard deviation | Minimum | Maximum | Mean | Standard deviation | Minimum | Maximum |
| 1899–1909 | 0.25 | 0.17 | 0.07 | 0.88 | 0.23 | 0.16 | 0.06 | 0.86 |
| 1910–1919 | 0.36 | 0.20 | 0.07 | 1.00 | 0.26 | 0.15 | 0.06 | 0.87 |
| 1920–1929 | 0.51 | 0.24 | 0.06 | 1.50 | 0.24 | 0.12 | 0.03 | 0.73 |
| 1930–1939 | 0.53 | 0.28 | 0.13 | 1.33 | 0.30 | 0.16 | 0.07 | 0.75 |
| 1940–1949 | 1.88 | 1.09 | 0.35 | 4.38 | 0.80 | 0.47 | 0.15 | 1.85 |
| 1950–1959 | 1.51 | 0.66 | 0.42 | 3.50 | 0.45 | 0.22 | 0.15 | 1.19 |
| 1960–1969 | 4.31 | 9.65 | 1.25 | 150.00 | 0.82 | 1.86 | 0.24 | 29.09 |
| 1970–1979 | 29.96 | 58.30 | 1.33 | 1,050.00 | 2.22 | 3.83 | 0.16 | 53.75 |
| 1980–1989 | 90.84 | 157.45 | 3.33 | 2,090.00 | 2.96 | 4.97 | 0.13 | 62.56 |
| 1990–1999 | 174.05 | 358.15 | 11.00 | 7,150.00 | 3.55 | 6.97 | 0.25 | 135.10 |
| 2000–2009 | 300.34 | 542.81 | 26.21 | 8,250.00 | 4.86 | 8.95 | 0.39 | 132.03 |
| 2010–2012 | 758.46 | 1,161.84 | 80.50 | 8,510.00 | 10.04 | 15.63 | 1.04 | 110.42 |

**Table 2**

Hedonic regression results

The table presents estimates from our hedonic regressions using ordinary least squares. The dependent variable is the average price (in real British pounds) per bottle per quartet of year-end, château, vintage, and transaction type. Yield data (for an anonymous First Growth) come from Chevet, Lecocq, and Visser (2011). The weather quality variable is based on temperature during the growing season and rainfall during the harvest season of each vintage year. All age variables are converted from years to centuries: age has been divided by one hundred, age$^2$ by ten thousand, etc. Robust standard errors are clustered at the year level and reported in parentheses beneath the coefficients. *, **, and *** denote significance at the 0.10, 0.05, and 0.01 level, respectively.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dealer | 0.07 | 0.23*** | 0.50*** | 0.26*** | 0.50*** | 0.49*** |
| | (0.07) | (0.07) | (0.06) | (0.06) | (0.05) | (0.05) |
| Lafite | 0.43*** | | | 0.31*** | 0.16*** | 0.16*** |
| | (0.04) | | | (0.04) | (0.03) | (0.03) |
| Latour | 0.26*** | | | 0.22*** | 0.17*** | 0.17*** |
| | (0.03) | | | (0.02) | (0.02) | (0.02) |
| Margaux | 0.11*** | | | 0.08*** | 0.04** | 0.04** |
| | (0.02) | | | (0.02) | (0.02) | (0.02) |
| Mouton | 0.36*** | | | 0.37*** | 0.31*** | 0.31*** |
| | (0.04) | | | (0.04) | (0.04) | (0.04) |
| Ln(yield) | | -0.71*** | | -0.70*** | -0.21*** | -0.21*** |
| | | (0.04) | | (0.04) | (0.02) | (0.02) |
| Weather quality | | 0.08*** | | 0.08*** | 0.07*** | 0.04*** |
| | | (0.00) | | (0.00) | (0.00) | (0.01) |
| Age | | | 3.01*** | | 2.90*** | -0.80 |
| | | | (0.46) | | (0.38) | (0.96) |
| Age$^2$ | | | -1.58* | | -2.25*** | 5.87** |
| | | | (0.82) | | (0.75) | (2.44) |
| Age$^3$ | | | 0.89** | | 1.28*** | -2.96* |
| | | | (0.43) | | (0.43) | (1.56) |
| Age × weather quality | | | | | | 0.32*** |
| | | | | | | (0.09) |
| Age$^2$ × weather quality | | | | | | -0.69*** |
| | | | | | | (0.23) |
| Age$^3$ × weather quality | | | | | | 0.36** |
| | | | | | | (0.15) |
| Year dummies? | Yes | Yes | Yes | Yes | Yes | Yes |
| *F*-test age variables | | | 439.36*** | | 248.91*** | 60.37*** |
| *F*-test age-quality variables | | | | | | 8.05*** |
| *N* | 9,492 | 9,224 | 9,492 | 9,224 | 9,224 | 9,224 |
| *R*-squared | 0.45 | 0.61 | 0.69 | 0.62 | 0.73 | 0.74 |

**Table 3**

Aging and wine prices

The table shows estimates of the geometric average price appreciation over different segments of the life cycle for our benchmark model (reported in the last column of Table 2) and for a number of alternative specifications of the hedonic model. ** and *** denote significance at the 0.05 and 0.01 level, respectively.

| | *F*-test age-quality variables | Estimates of annualized price appreciation over life cycle | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Lowest-quality vintages | | | Highest-quality vintages | | | | |
| | | Age 0–20 | Age 20–40 | Age 40–60 | Age 0–20 | Age 20–40 | Age 40–60 | Age 60–80 | Age 80–100 |
| Benchmark model | 8.05*** | 0.6% | 1.9% | 2.7% | 4.0% | 2.0% | 0.9% | 0.9% | 1.7% |
| Before 1980 | 29.05*** | -0.8% | 2.3% | 3.8% | 5.9% | 1.3% | -0.5% | 0.5% | 4.3% |
| Since 1980 | 3.37** | 1.4% | 1.7% | 2.0% | 3.1% | 2.1% | 1.4% | 1.1% | 1.3% |
| Auction data only | 6.62*** | 1.1% | 2.1% | 2.6% | 3.6% | 1.8% | 0.9% | 0.9% | 1.8% |
| Fourth-order age polynomial | 8.37*** | 0.8% | 1.9% | 2.7% | 3.0% | 2.4% | 1.1% | 0.4% | 1.7% |
| Add data on winter rainfall | 4.75*** | 1.1% | 2.1% | 2.7% | 3.4% | 1.9% | 1.2% | 1.2% | 1.8% |
| Price-based quality measure | 34.86*** | 1.0% | 2.5% | 3.3% | 4.5% | 1.8% | 0.4% | 0.3% | 1.5% |

**Table 4**

Wine versus other assets 1900–2012

The table shows the distribution of returns (in nominal and real British pounds) for wine and other assets over the period 1900–2012. A deflated wine price index is estimated by applying a value-weighted arithmetic repeat-sales regression to the price pairs in our database. The resulting return estimates are corrected for storage and insurance costs. Data on British equities, government bonds, bills, and inflation are from Dimson, Marsh, and Staunton (2013). Art return data are from Goetzmann, Renneboog, and Spaenjers (2011), updated until end-2012 using data from Artprice (2013). Stamp return data are from Dimson and Spaenjers (2011), updated using the Stanley Gibbons GB30 index.

| | Mean returns per annum | | Dispersion of annual returns | | | | |
|---|---|---|---|---|---|---|---|
| | Geometric | Arithmetic | Standard deviation | Lowest | | Highest | |
| *Nominal returns* | | | | | | | |
| Wine | 8.2% | 10.9% | 26.9% | -34.9% | 1949 | 144.3% | 1942 |
| Equities | 9.4% | 11.2% | 21.6% | -48.8% | 1974 | 145.6% | 1975 |
| Bonds | 5.5% | 6.1% | 11.9% | -17.4% | 1974 | 53.1% | 1982 |
| Bills | 4.9% | 5.0% | 3.8% | 0.3% | 2012 | 17.2% | 1980 |
| Art | 6.4% | 7.2% | 13.2% | -31.2% | 1930 | 46.6% | 1968 |
| Stamps | 6.9% | 7.6% | 13.5% | -8.8% | 1982 | 83.2% | 1979 |
| Inflation | 3.9% | 4.2% | 6.5% | -26.0% | 1921 | 24.9% | 1975 |
| *Real returns* | | | | | | | |
| Wine | 4.1% | 6.7% | 26.3% | -37.1% | 1949 | 145.6% | 1942 |
| Equities | 5.2% | 7.1% | 19.8% | -57.1% | 1974 | 96.7% | 1975 |
| Bonds | 1.5% | 2.4% | 13.7% | -30.7% | 1974 | 59.4% | 1921 |
| Bills | 0.9% | 1.1% | 6.3% | -15.7% | 1915 | 43.0% | 1921 |
| Art | 2.4% | 3.1% | 12.4% | -29.7% | 1915 | 38.4% | 1968 |
| Stamps | 2.8% | 3.5% | 12.3% | -19.2% | 1915 | 56.3% | 1979 |

**Table 5**

Predictability of the returns on collectibles

Panel A shows the correlations of the five-year returns on wine, art, and stamps with two return predictors. Panel B shows the results of a set of regressions with the five-year return on a collectible as the dependent variable. Standard errors adjusted using the Newey-West procedure (with four lags) are reported in parentheses below the coefficients. Returns to wine are estimated in this paper. Returns to art are from Goetzmann, Renneboog, and Spaenjers (2011), updated through the end of 2012 using data from Artprice (2013). Returns to stamps are from Dimson and Spaenjers (2011), updated using the Stanley Gibbons GB30 index. Cyclically adjusted price-dividend ratios are taken from Dimson, Marsh, and Staunton (2013) and subsequently trend-adjusted.

*Panel A: Correlations*

| | Five-year real returns | | |
|---|---|---|---|
| | Wine | Art | Stamps |
| Prior performance relative to other collectibles | -0.28 | -0.28 | -0.13 |
| Prior cyclically adjusted price-dividend ratio of equities | -0.20 | -0.20 | -0.16 |

*Panel B: Regressions*

| | Sample | | |
|---|---|---|---|
| | All | Until 1955 | After 1955 |
| Prior performance relative to other collectibles | -0.22*** | -0.25*** | -0.19* |
| | (0.08) | (0.09) | (0.11) |
| Prior cyclically adjusted price-dividend ratio of equities | -0.30** | -0.35 | -0.24 |
| | (0.14) | (0.21) | (0.17) |
| Collectible fixed effects? | Yes | Yes | Yes |
| *N* | 312 | 156 | 156 |
| *R*-squared | 0.13 | 0.15 | 0.14 |

*Panel A: Low-quality vintage*

*Panel B: High-quality vintage*

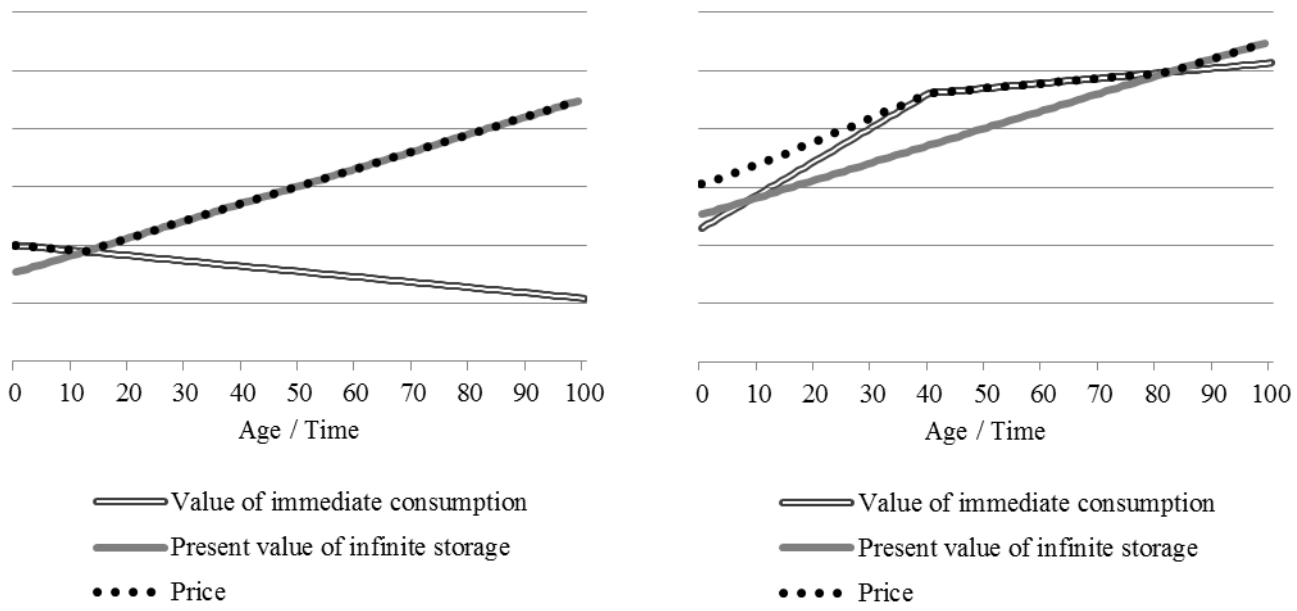
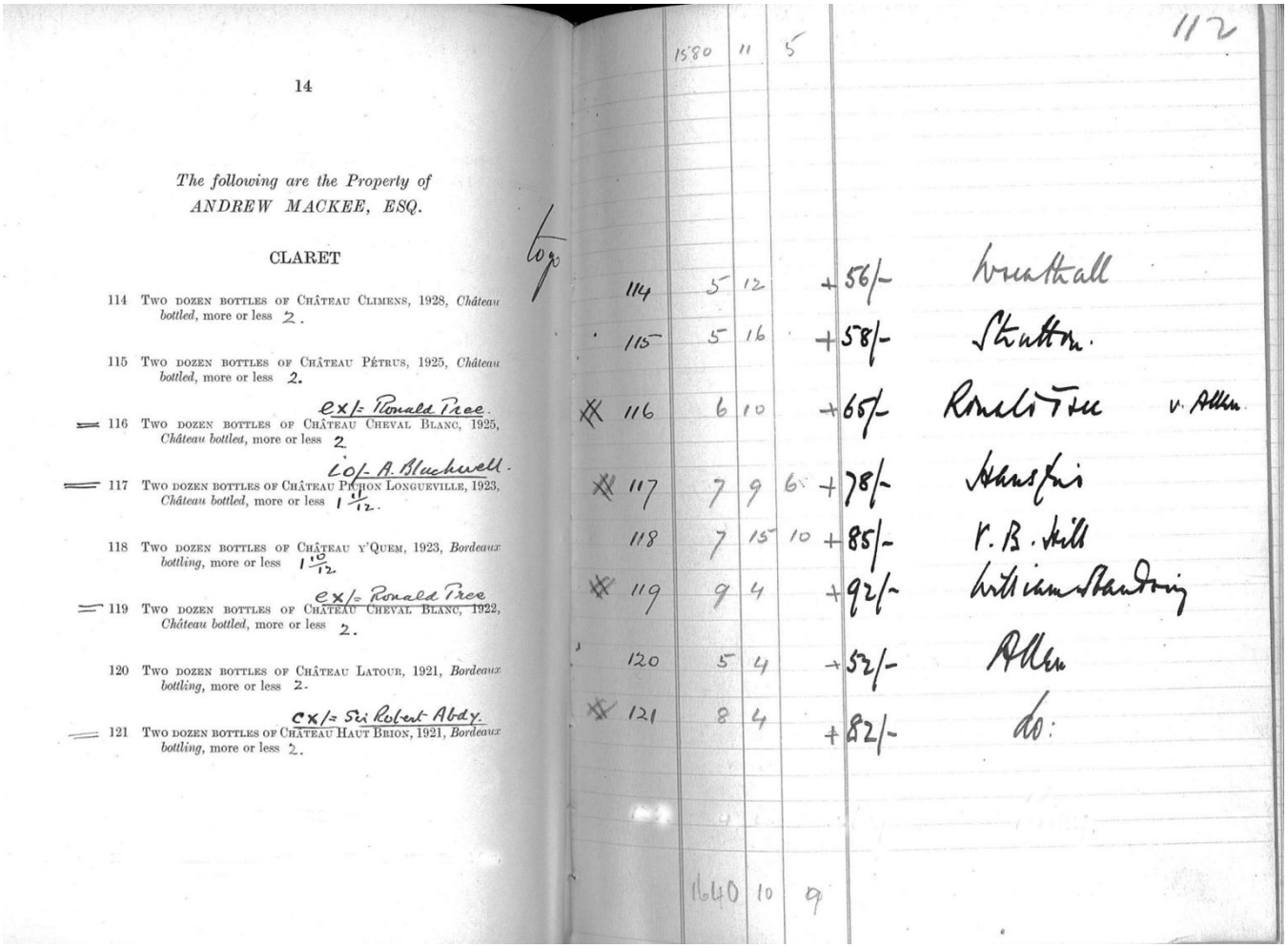



**Fig. 1.** An illustrative model of wine prices. The figure shows examples of life-cycle log price patterns implied by the model described in Section 2 for a low-quality vintage that starts deteriorating in drinkability immediately after the vintage (in Panel A) and a high-quality vintage for which drinkability first improves for 40 years and then remains constant (in Panel B). The following parameter values were used: $r$ = 10%, $g$ = 5%, $z$ = 2%, $a$ = 0.96, $b$ = 1.12, and $d_{L,1} = 0.10 \times d_{H,1} = 0.01 \times c_{L,0} = 0.01 \times 0.50 \times c_{H,0}$.



14

*The following are the Property of*
*ANDREW MACKEE, ESQ.*

CLARET

114 Two dozen bottles of Château Climens, 1928, *Château bottled*, more or less 2.

115 Two dozen bottles of Château Pétrus, 1925, *Château bottled*, more or less 2.

ex/= Ronald Tree.
116 Two dozen bottles of Château Cheval Blanc, 1925, *Château bottled*, more or less 2.

10/- A. Blackwell.
117 Two dozen bottles of Château Pichon Longueville, 1923, *Château bottled*, more or less 1 11/12.

118 Two dozen bottles of Château y'Quem, 1923, *Bordeaux bottling*, more or less 1 10/12.

ex/= Ronald Tree
119 Two dozen bottles of Château Cheval Blanc, 1922, *Château bottled*, more or less 2.

120 Two dozen bottles of Château Latour, 1921, *Bordeaux bottling*, more or less 2.

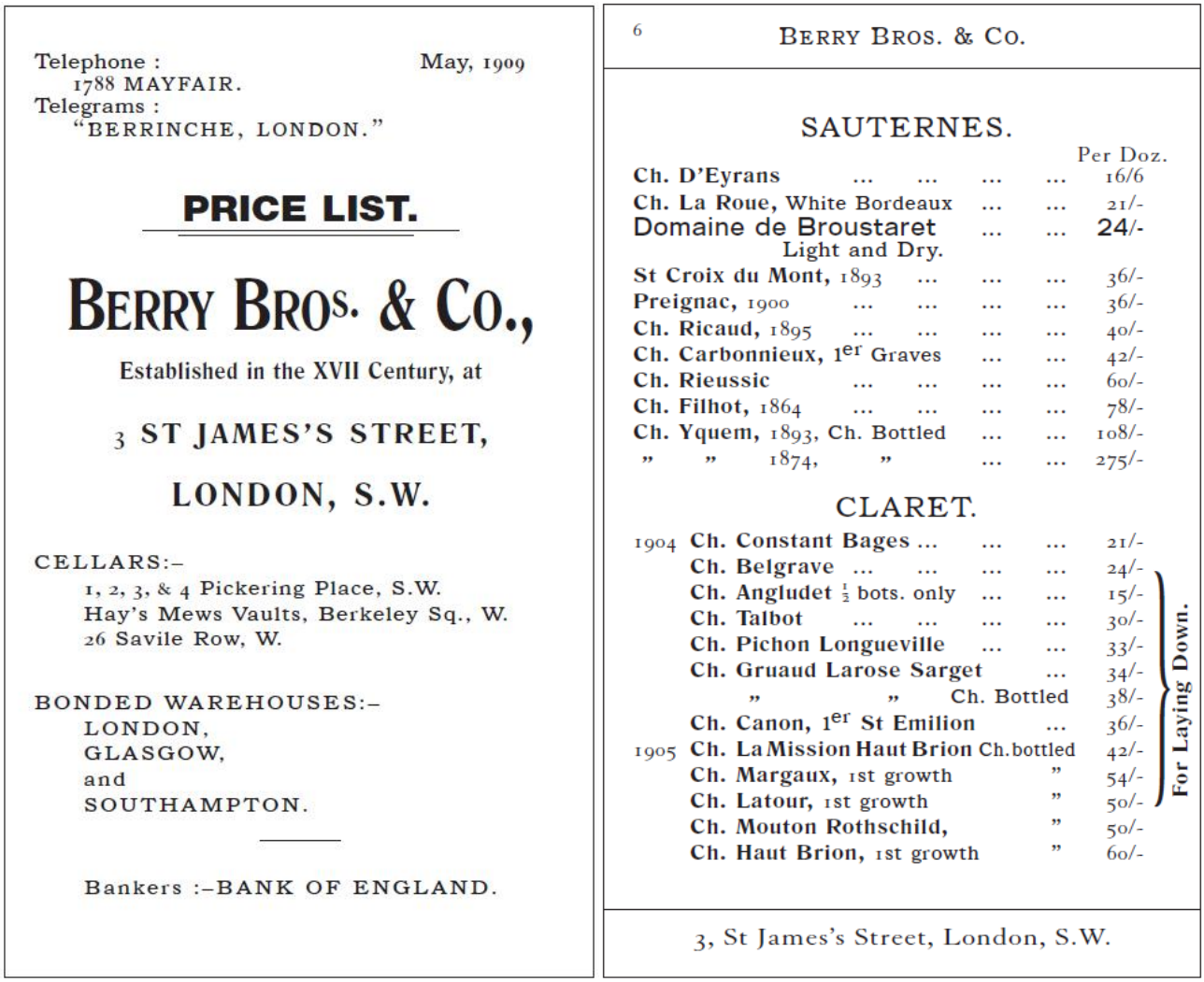
CX/= Sir Robert Abdy.
121 Two dozen bottles of Château Haut Brion, 1921, *Bordeaux bottling*, more or less 2.

1580 11 5

112

| | | | | | |
|---|---|---|---|---|---|
| 114 | 5 | 12 | | +56/- | Wrathall |
| 115 | 5 | 16 | | +58/- | Stratton. |
| 116 | 6 | 10 | | +65/- | Ronald Tree v. Allen |
| 117 | 7 | 9 | 6 | +78/- | Hanson |
| 118 | 7 | 15 | 10 | +85/- | R. B. Hall |
| 119 | 9 | 4 | | +92/- | William Standring |
| 120 | 5 | 4 | | +52/- | Allen |
| 121 | 8 | 4 | | +82/- | do: |
| | 64 | 10 | 9 | | |

**Fig. 2.** Christie's auction catalogue (© Christie's). The figure shows an excerpt (lots 114–121) from the annotated catalogue of the wine auction that took place at Christie's London on December 9, 1935. The left page is from the original pre-sale catalogue and contains some handwritten notes of the auctioneer on the number of bottles in each lot and on commission bids submitted prior to the sale. The right page was added by the auctioneer and shows the price paid for each lot (in pounds, shillings, and pence), the equivalent price (in shillings) per dozen bottles, and the name of the buyer.



Telephone :
1788 MAYFAIR.
Telegrams :
"BERRINCHE, LONDON."

May, 1909

**PRICE LIST.**

# BERRY BROS. & CO.,

Established in the XVII Century, at

3 ST JAMES'S STREET,

LONDON, S.W.

CELLARS:–
1, 2, 3, & 4 Pickering Place, S.W.
Hay's Mews Vaults, Berkeley Sq., W.
26 Savile Row, W.

BONDED WAREHOUSES:–
LONDON,
GLASGOW,
and
SOUTHAMPTON.

Bankers :–BANK OF ENGLAND.



## SAUTERNES.

| | | Per Doz. |
|---|---|---|
| | Ch. D'Eyrans ... ... ... ... | 16/6 |
| | Ch. La Roue, White Bordeaux ... ... | 21/- |
| | Domaine de Broustaret ... ... | 24/- |
| | Light and Dry. | |
| | St Croix du Mont, 1893 ... ... ... | 36/- |
| | Preignac, 1900 ... ... ... ... | 36/- |
| | Ch. Ricaud, 1895 ... ... ... ... | 40/- |
| | Ch. Carbonnieux, 1er Graves ... ... | 42/- |
| | Ch. Rieussic ... ... ... ... | 60/- |
| | Ch. Filhot, 1864 ... ... ... ... | 78/- |
| | Ch. Yquem, 1893, Ch. Bottled ... ... | 108/- |
| | " " 1874, " ... ... | 275/- |

## CLARET.

| | | | |
|---|---|---|---|
| 1904 | Ch. Constant Bages ... ... ... | 21/- | For Laying Down. |
| | Ch. Belgrave ... ... ... ... | 24/- | |
| | Ch. Angludet ½ bots. only ... ... | 15/- | |
| | Ch. Talbot ... ... ... ... | 30/- | |
| | Ch. Pichon Longueville ... ... | 33/- | |
| | Ch. Gruaud Larose Sarget ... | 34/- | |
| | " " Ch. Bottled | 38/- | |
| | Ch. Canon, 1er St Emilion ... | 36/- | |
| 1905 | Ch. La Mission Haut Brion Ch. bottled | 42/- | |
| | Ch. Margaux, 1st growth " | 54/- | |
| | Ch. Latour, 1st growth " | 50/- | |
| | Ch. Mouton Rothschild, " | 50/- | |
| | Ch. Haut Brion, 1st growth " | 60/- | |



**Fig. 3.** Berry Bros. & Rudd price list (© Berry Bros. & Rudd). The figure shows two pages from the May 1909 price list. Prices are quoted in shillings per dozen bottles.

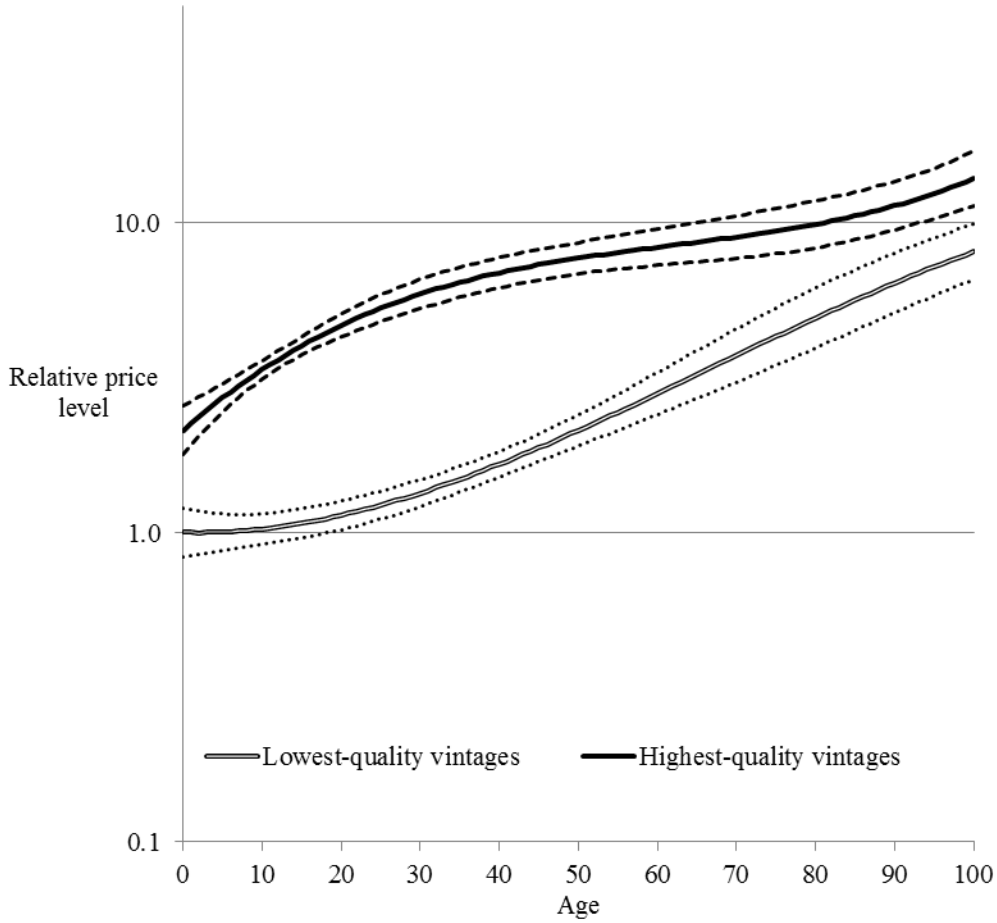



**Fig. 4.** Aging and wine prices. The figure shows the predicted life-cycle price patterns for the lowest-quality and highest-quality vintages as implied by the coefficients on the weather quality variable, age variables, and the age-quality interaction terms in the benchmark model (reported in the last column of Table 2). Age is expressed in years. The price level for the lowest-quality category at age zero is set to unity. The dotted lines denote 95% confidence intervals.

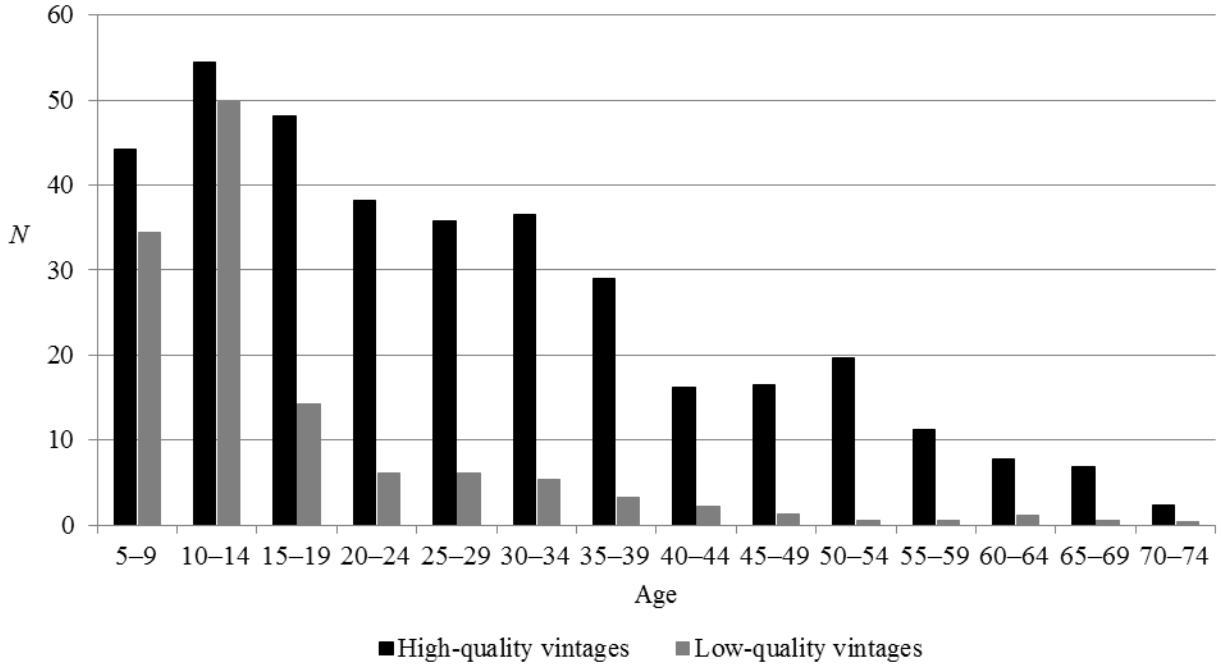



**Fig. 5.** Aging and wine transactions at auction. The figure shows life-cycle average annual auction volume patterns for low-quality and high-quality vintages, based on the number of sold lots at Christie's London per combination of vintage year and sale year between 1985 and 2012. Age is expressed in years. We compute the average annual auction volume for each age both for relatively low-quality wines (weather quality < 8) and for relatively high-quality wines (weather quality > 12). We then average over five-year age groups (starting with ages 5–9).

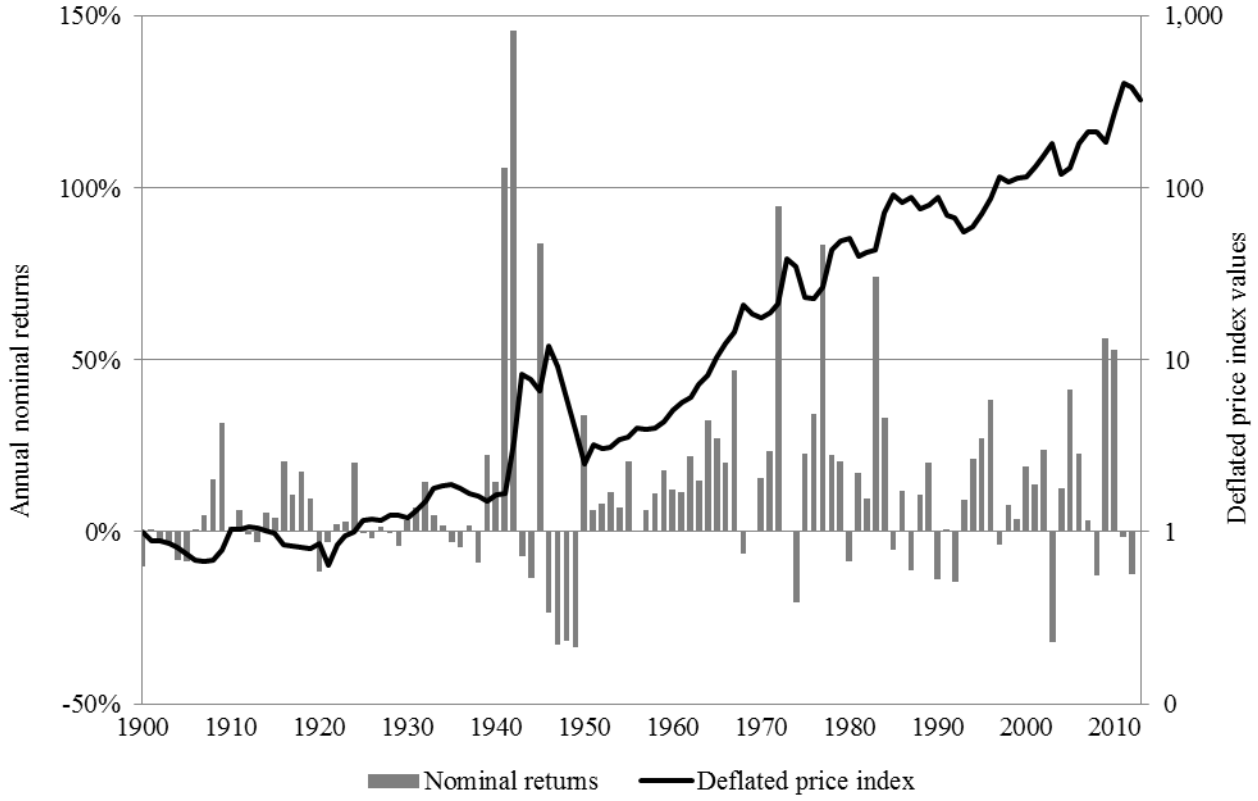



**Fig. 6.** Deflated wine price index and nominal returns. The line in the figure shows a wine price index in real British pounds (against the right-hand axis), which is estimated by applying a value-weighted arithmetic repeat-sales regression to the price pairs in our database over the period 1900–2012. The index is set to unity at the start of 1900. Index levels in this graph are not adjusted for storage or insurance costs. The bars show the estimated nominal return for each year (against the left axis).

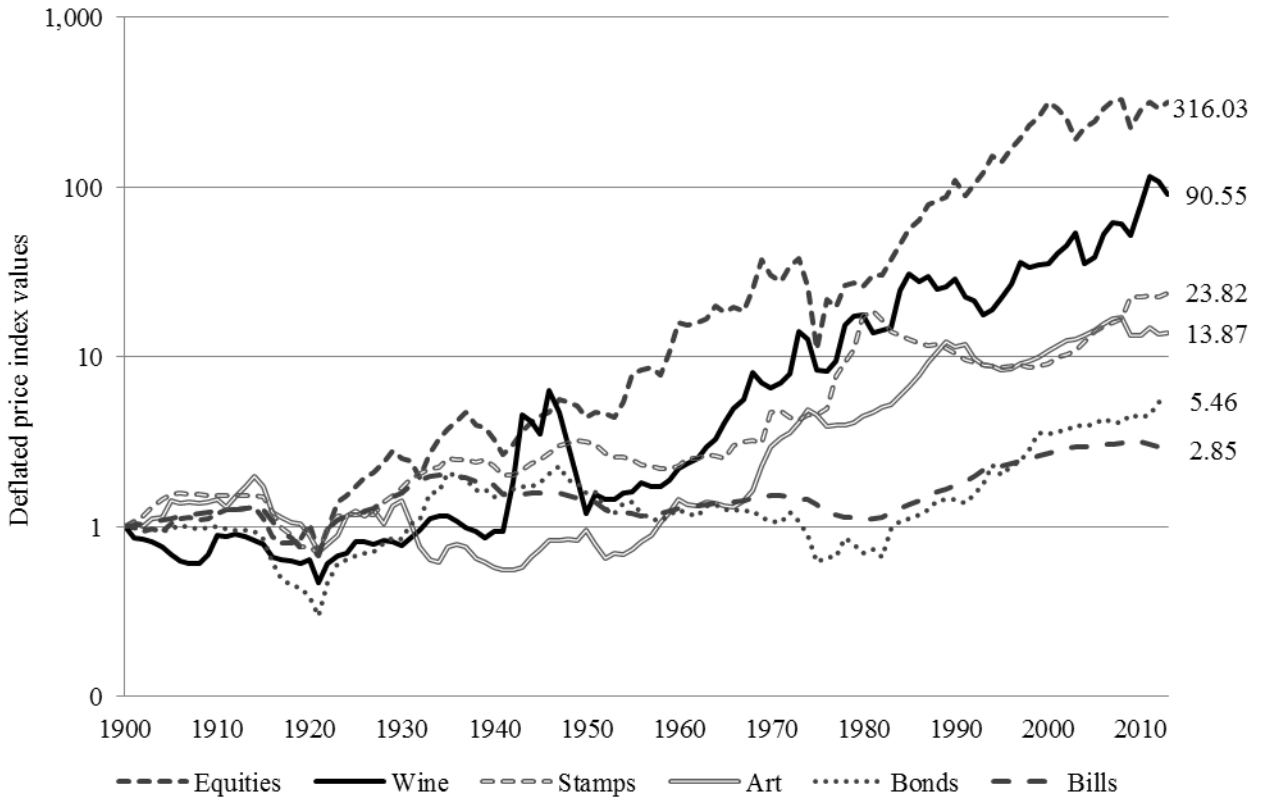



**Fig. 7.** Wine versus other assets 1900–2012. The figure shows price indexes in real British pounds for wine and other assets over the period 1900–2012. A deflated wine price index is estimated by applying a value-weighted repeat-sales regression to the price pairs in our database. The resulting return estimates from Fig. 6 are corrected here for storage and insurance costs. Returns on British equities, government bonds, and bills include reinvested income. These returns and inflation are from Dimson, Marsh, and Staunton (2013). Returns to art are from Goetzmann, Renneboog, and Spaenjers (2011), updated through the end of 2012 using data from Artprice (2013). Returns to stamps are from Dimson and Spaenjers (2011), updated using the Stanley Gibbons GB30 index. All indexes are set to unity at the start of 1900.