Wine Economics

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Wine and Finance

Whoever said that money can't buy happiness simply didn't know where to go shopping.
—A phrase attributed to Bo Derek

This chapter is divided into two sections. The first describes the opportunities to benefit, in terms of both expected return and portfolio diversification, from investments that include the purchase of bottles of wine and shares of wine companies listed on the stock exchange. Bottles of wine have a special nature because they have both investment and consumption value affecting the agent's utility. They are sold in the secondary market by auction firms like Christie's, Sotheby's, Zachy's, and Acker Merrall & Condit, and their sales amounted to $350 million in 2015. There are, in addition, sales over the internet (e.g., on eBay), which are difficult to quantify. (For a detailed description of how wine auctions work, see Cardebat, 2017, pp. 109–117.)

Looking at the sole expected return is not sufficient to compare assets because they carry different degrees of risk. The Sharpe ratio is given by the performance of an investment adjusted for its risk: $E(r)/\sigma$, where $E(r)$ is the expected return and σ the standard deviation. When investing in a diversified portfolio of assets, the standard deviation is connected to two types of risk: market risk and firm-specific risk. The former cannot be eliminated because it depends on factors which affect the whole economy (gross domestic product growth rate, exchange rates, shocks to oil prices, etc.) while the latter can be reduced or even removed with an accurate diversification strategy. Therefore, one should also consider the correlation of the expected performance of an asset with that of the market. In fact, assets whose expected return is negatively correlated with that of the market are valuable because they are countercyclical. This insurance function comes at a cost. Assets with negative correlations with market returns should have lower expected returns. This model, known as the capital asset pricing model (CAPM), has been extended to include additional elements, as in Fama and French's three-factor model (1992, 1993, 1995). Appendix 5.1 provides a review of the theoretical concepts used throughout the section.

When comparing assets, we should take into account the peculiarities of markets that can generate additional sources of risk. The first one is the liquidity risk connected to the amount of time necessary for the sale and the uncertainty about the realized price; from this point of view, financial markets are more liquid than real estate and bottles of wine markets. The second one is the risk of counterfeiting, and in the case of bottles of wine it is always present but increases exponentially if performed by unknown private sellers.

The second section deals with the instruments to hedge risk, such as insurance and derivatives, to cope with catastrophic weather events and exchange rate fluctuations.

5.1 Investments

5.1.1 Investments in Bottles of Wine

There is a widespread belief that the purchase of collectibles, like works of art, stamps, and bottles of wine, are a valid alternative form of investment or can be complementary to traditional forms, like shares and debt securities. However, empirical studies have largely rejected these conjectures and demonstrated that collectible items have an unfavorable profile characterized by low yield and high risk (Burton and Jakobsen, 1999; Mandel, 2009). Baumol (1986) measured the real annual performance of paintings from 1652 to 1961. The data, collected by Reitlinger (1961), concerned auctions held predominantly in London and so until 1920 refer almost exclusively to sales at Christie's. Based on the author's calculations, the real yield rate was only 0.55 percent. Frey and Pommerehne (1989) extended Baumol's (1986) database to 1987 and included auctions in other countries. The authors came to similar conclusions, with an unattractive real rate yield of 1.4 percent between 1635 and 1949 and 1.6 percent between 1950 and 1987. Pesando (1993) analyzed the price of modern prints between 1977 and 1992 and found a real annual return of 1.51 percent, which is significantly lower than for shares and bonds in the same time span, while risk, defined as the standard deviation of portfolio returns, is the same or even higher.

More favorable results were obtained by Mei and Moses (2002) and Dimson and Spaenjers (2011). The first, with data relating to works of art sold in the period 1875–2000, found higher returns than for bonds, though lower than for shares, and a certain power of diversification. The second, instead, focused on stamps, which, like the works of art in Mei and Moses (2002), earn more than bonds but less than shares and can help to diversify risk, given the low correlation with equity returns.

Articles about the wine sector that are completely anecdotal, without any statistical basis, fantasizing about amazing returns and recommending purchases for investment purposes frequently appear. Hugh Johnson (1971),[1] for example, suggested buying bottles, letting them rest in the cellar for a few years, and then selling them because they will increase in value. An article written by Prial (1997) appeared in the

New York Times and reported on the boom in Bordeaux prices in 1996 (especially in cellars like Petrus and Chateau Ausone) and burgundy (Domaine de la Romanée-Conti). In the Italian newspaper *Corriere della Sera*, Ferraro (2014) compared the prices of the Ornellaia wine from 2007 to 2014 with those of some alternative investments (Standard & Poor's [S&P] 500, Financial Times Stock Exchange 100, gold and oil) and titled his article "Investing in Big Reds? Better than Gold and Oil." But clearly, no scientific conclusion can be drawn about the average profitability of investments in wine by taking into consideration only the bottle that gave the best results in the market in a limited period of time.

Indeed, academic studies (table 5.1) have provided conflicting results. A number of surveys have shown that wine is not an attractive investment because it does not offer higher returns and/or does not have a higher return-risk profile than other financial assets. Krasker (1979) used data from the Heublein auctions of Bordeaux red and Californian Cabernet Sauvignon wines between 1973 and 1977. To make the database homogenous, the author excluded the years prior to 1950 because wine stops maturing in a bottle after a certain number of years and, therefore, price changes can reflect, in part, the preferences toward antique goods that is a market in its own right. With a sample of only 137 observations, the expected return from stocking wine was no different to a risk-free asset. Wine storage costs, not detailed by any archive but econometrically estimated, amounted to $1.40 per year per bottle. Although a series of arguments were put forward to justify this figure, the author himself admitted that it seemed to be very high.

Weil (1993) adopted a different approach because it followed an investor's purchases from 1980 to 1992 rather than looking at auction prices. With an average yield of 9.5 percent and with 11 percent peaks for Bordeaux wines, the purchase of wine for investment purposes was less profitable than stocks in the New York Stock Exchange in the same period. Di Vittorio and Ginsburgh (1994), with a sample of about thirty thousand red wines from Bordeaux (vintages 1949–1989) sold at Christie's auctions, showed a price increase of 75 percent between 1981 and 1990 and a subsequent decrease of 15 percent in the following years. The average yield amounted to 4.2 percent, with strong variability between châteaux and a correlation with the weather conditions of the year.

Burton and Jakobsen (2001) studied auction prices of Bordeaux red wines in various houses (Christie's, Sotheby's, Davis & Company, etc.) between 1986 and 1996, narrowing the survey to vintages after 1960. Unlike the other investigations, this considered the costs of transaction, storage, and insurance and is therefore the most complete, but it did not take into consideration transport costs and taxes. The yield of wine proved to be lower than the Dow Jones and higher than treasury bills; however, it is very volatile, which makes it an even less attractive type of investment. Further, the most expensive wines have a below average expected return. Bentzen,

Table 5.1
Main results on investments in bottles of wine.

					Costs					
Paper	Wines	Years	N	Methodology	Transaction	Transport	Storage	Insurance	Tax	Conclusions
Krasker (1979)	Bordeaux red wines and Californian Cabernet Sauvignon (years > 1950), Heublein auctions	1973–1977	137	Repeat sales	No	No	Estimated econometrically	No	No	Expected return from stocking wine was no different to a risk-free asset.
Jaeger (1981)	Bordeaux red wines and Californian Cabernet Sauvignon (years > 1950), Heublein auctions	1969–1977	199	Repeat sales	No	No	Used data from Freemark Abbey Winery	No	No	Positive return on wine compared with risk-free assets. Expected return and the risk for less expensive wines is greater than for more expensive wines.
Weil (1993)	French wines	1980–1992	70	Followed investor's purchases	n/a	n/a	n/a	n/a	n/a	Average return of 9.5%, with peaks of 11% for Bordeaux wines, much lower than the New York Stock Exchange in the same period.

Di Vittorio and Ginsburgh (1994)	Bordeaux red wines (1949–1989), Christie's auctions	1980–1992	29,901	Hedonic regressions of price with dummy variable	No	No	No	No	No	The prices of wines analyzed grew 75% between 1981 and 1990 and then fell 15%. Average return of 4.2% with strong variation between châteaux and correlation with the yearly weather conditions.
Burton and Jacobsen (2001)	Bordeaux red wines (years > 1960), various auction houses (Christie's, Sotheby's, Davis & Company, etc.)	1986–1996	10,558	Repeat sales	Yes	No	Yes	Yes	No	The return on wine was lower than treasury bills. The return on wine is, however, very volatile, which makes this type of investment even less attractive. The more expensive wines had a lower than average expected return.
Bentzen, Leth-Sorensen, and Smith (2002)	Bordeaux red wines (years > 1950), Copenhagen Wine Auctions-Bruun Rasmussen	1988–2002	48 auctions	Not very clear estimate method	No	No	No	No	No	Returns and volatility not reported.

(*continued*)

Table 5.1 (continued)

					Costs					
Paper	Wines	Years	*N*	Methodology	Transaction	Transport	Storage	Insurance	Tax	Conclusions
Fogarty (2006)	Australian wines, Langton auctions (years > 1965)	1989–2000	14,102	Adjacent period hedonic regressions of price	No	No	No	No	No	The return on Australian wine is probably higher than on French wines while the yield-risk profile is comparable with Australian equities.
Fogarty (2007)	French wines (using data from Burton and Jakobsen, 2001) and Australian wines (using data from Fogarty, 2006)	1986–1996 and 1989–2000	10,558 and 14,102	Repeat sales plus adjacent period hedonic regressions of price	Yes	No	Yes	No	Yes	Studies on wine underestimate the real return on this form of investment because it is either exempt from tax or subject to limited taxation in many countries. If this factor is taken into account, the actual yield of wine is higher. Wine, therefore, offers interesting investment opportunities, also by virtue of the power to diversify a securities portfolio.

Sanning, Shaffer, and Sharratt (2008)	Bordeaux red wines (years 1893–1998), Chicago Wine Company auctions	1996–2003	13,662	Repeat sales	No	No	No	No	No	Average monthly return of 0.51%, which rose to 0.78% if just the best wines were included. The monthly return was 0.75% higher than predicted by estimating both the CAPM and the Fama-French three-factor model and was poorly correlated with risk factors. Wine, therefore, offers interesting opportunities for investment and diversification.
Fogarty (2010b)	Australian wines, Langton auctions (years > 1965)	1990–2000	12,180	Repeat sales	No	No	No	No	No	Return on wine is lower than on traditional shares. Nevertheless, wine does benefit slightly from diversification.

(*continued*)

Table 5.1 (continued)

					Costs					
Paper	Wines	Years	*N*	Methodology	Transaction	Transport	Storage	Insurance	Tax	Conclusions
Masset and Henderson (2010)	Wines from various countries, Chicago Wine Company auctions (years 1981–2005)	1996–2009	More than 400,000	Repeat sales	No	No	No	No	No	Fine wines had higher returns and lower volatility than equities, especially in times of crisis. Adding wine brought benefits in terms of diversification and average expected risk while the CAPM estimate showed a positive and significant alpha between 1996 and 2009 and a very low beta.
Cardebat and Figuet (2010)	French wines of Bordeaux; auctions in the United States, Great Britain, and France (131 years and 486 châteaux)	n.a.	53,153	Repeat sales	No	No	No	No	No	CAPM and Fama-French Three-Factor model estimates as in Sanning, Shaffer, and Sharratt (2008). Negative excess return (alpha null) but power of diversification as in Sanning, Shaffer, and Sharratt (beta null).

Fogarty and Jones (2011)	Australian wines, Langton auctions (years > 1965)	1988–2000	14,102	Hedonic approach, repeat sales and hybrid model	No	No	No	No	No	Return on wine and benefits and its benefits in terms of portfolio diversification are influenced by the estimation methodology adopted (hedonic models, repeat sales, and hybrid models).
Devine and Lucey (2015)	Red wines of Bordeaux and the Rhône, Chicago Wine Company auctions	1996–2007	51,756 and 18,147	Repeat sales	No	No	No	No	No	Wine offers higher returns than risk-free securities but with a more favorable return/risk ratio than shares. When the individual subregions are taken into consideration, the returns become more volatile so investment in wine should be limited to experts only.
Dimson, Rousseau, and Spaenjers (2015)	Bordeaux Premiers Crus	1900–2012	9,492	Arithmetic repeat-sales regression	No	No	Yes	Yes	No	The real financial return to wine investment is 4.1%, which exceeds government bonds, art, and investment-quality stamps. Wine appreciation is positively correlated with stock market returns.

Leth-Sorensen, and Smith (2002) analyzed data on Bordeaux red wines of years after the 1950s (therefore excluding “antique goods”), which were sold in forty-eight Bruun Rasmussen auctions in Copenhagen between 1988 and 2002, but did not report on returns and volatility.

A series of other studies, however, came to opposite conclusions. Jaeger (1981) developed the Krasker study (1979) using the same database but extended the time horizon to the period 1969–1977 because the years 1973–1977 were particularly unfavorable and distorted the results. With an additional four years and sixty-two observations and using data from the Freemark Abbey Winery on the actual storage costs, the analysis showed a positive return on wine compared with risk-free securities. Fogarty (2006) collected data on Australian wines sold at Langton auctions between 1989 and 2000 and concluded that the yield on Australian wine is probably higher than on French wines while the yield-risk profile is comparable with Australian equities. Wine, therefore, appears to be a good form of investment. In the following year Fogarty (2007) broadened the survey by extending the database and considering the effects of taxation. The data on French wines were the same as those used by Burton and Jakobsen (2001) while the Australian data were the same as Fogarty (2006). The author emphasized how studies on wine underestimated the real performance of this form of investment since auction transactions are tax-exempt or subject to limited taxation in many countries. If this factor is taken into account, the actual yield of wine is higher. For this reason, wine offers interesting investment opportunities, also by virtue of its ability to diversify a securities portfolio.

Sanning, Shaffer, and Sharratt (2008) applied the CAPM and the Fama-French three-factor model to Bordeaux red wines of the years 1893–1998 sold at auction between 1996 and 2003 at the Chicago Wine Company and found an average monthly rate of return of 0.51 percent, which rose to 0.78 percent if just the best wines were included. The monthly return was 0.75 percent higher than predicted by estimating both the CAPM and the Fama-French three-factor model (alpha coefficient) and was poorly correlated with risk factors (beta coefficients). Fogarty (2010b), using data on Langton auctions during the years 1990–2000, found that the yield on wine is lower than on traditional shares. Nevertheless, wine provides a (modest) diversification benefit.

In Masset and Henderson’s (2010) study, using data on wines from various countries sold at auction between 1996 and 2009 at the Chicago Wine Company (vintages 1981–2005), the best bottles (fine wines) had higher returns and lower volatility than equities, especially in times of crisis. Adding wine brought benefits in terms of diversification and average expected risk while the estimate of the CAPM showed a higher return than expected in the model (positive and significant alpha) and a poor correlation with market performance (very low beta). Fogarty and Jones (2011), using Australian Langton auction data from the period 1988–2000, demonstrated that the yield on wine and its benefits in terms of portfolio diversification depend on the estimation methodology adopted (hedonic models, repeat sales, and hybrid models were used in the study).

Cardebat and Figuet (2010) replicated the study by Sanning, Shaffer, and Sharratt (2008) with different data relating to the Bordeaux wines of 486 châteaux and found no excess return (alpha null) with both the CAPM and with the Fama-French three-factor model, but some power of diversification (beta null) as in Sanning, Shaffer, and Sharratt (2008). Devine and Lucey (2015), using data on the red wines of Bordeaux and Rhône sold at the auctions of the Chicago Wine Company between 1996 and 2007, concluded that wine offers higher returns than risk-free securities but with a more favorable return/risk ratio than shares. When the individual subregions are taken into consideration, the returns become more volatile, so only experts should invest in wine. Lastly, Dimson, Rousseau, and Spaenjers (2015) used data from Premier Cru Bordeaux over the period 1900–2012 and estimated a real financial return on wine investment of 4.1 percent, which exceeds government bonds, art, and investment-quality stamps.

From this quick review we can easily see how the scientific literature has not yet managed to reach some kind of consensus on the question of the opportunity and profitability of investments in wine. As in all empirical analyses, this may be due to the fact that using different databases and estimation methodologies can change the results significantly so that so-called "stylized facts" cannot be identified.[2] Moreover, as Fogarty and Jones (2011) pointed out, wine sales are not very frequent and require specific econometric methodologies that can produce variable results. An additional problem is that the estimated return of investment from wine bottles is influenced by the calculation method. Fogarty and Sadler (2016) applied six different methodologies to French data and showed that results change significantly. The comparison between financial assets and bottles of wine is made even more problematic by the following critical issues.

1. Wine and securities are not homogeneous in terms of costs, benefits, risk, and the degree of liquid assets.

    - *Costs*: Most studies on wine (see table 5.1) do not take into consideration transaction, transport, storage, and insurance costs (Fogarty, 2006). The estimated return on wine purchases is therefore overestimated compared with traditional financial assets which only have transaction costs. Further, unlike the transfer of securities, the cost of transporting wine depends on the final destination while storage costs are influenced by climate so the same purchase by investors in different countries may present different net returns. The same applies to the direct participation in the auction that involves direct (monetary) and indirect (opportunity) costs.

- *Benefits*: Calculating the performance of an asset must take into consideration all costs and benefits produced, not just those of an economic nature. Unlike normal financial assets, collectibles—such as, for example, works of art, stamps, and also wine—generate utility for those who own them. Art works and stamps can be enjoyed by the owner and their guests, and possession alone can be a source of pride (Burton and Jakobsen, 2001; Mandel, 2009). If these psychological benefits are added to the expected return and risk in the investor utility function, then it is easier to justify the low returns on investment in art found in the literature (for a review, see Mandel, 2009). Wine, however, is different from other collectibles since to be enjoyed it has to be drunk and, therefore, destroyed. The only flow of benefits before its destruction is the possible gratification of possessing a cellar full of prestigious labels, but this would hardly seem likely to have a significant impact on the investor's utility function and make them ready to sacrifice part of the expected return from an alternative investment.
- *Risk*: The literature has not studied how the type of wine storage, whether at home or in specialized companies, can affect the resale price at auction. It may well be that wine held in a personal cellar provides fewer guarantees for the conservation of the product under optimal conditions, and therefore, it may be more difficult to resell.
- *Liquidity*: A comparison of the returns corrected for risk takes into account only the volatility of the asset price of financial resources but not the greater liquidity of securities. These can be sold in real time, whereas the liquidation of a winery usually takes four to five months (Burton and Jakobsen, 2001).

2. *Taxes*: A comparison between the return on traditional financial assets and bottles of wine is complicated by the different tax treatment of the two investment forms. In many countries, in fact, the sale of bottles is tax free (Burton and Jakobsen, 2001; Fogarty, 2007). This tends to underestimate the performance of wine.
3. The purchase of bottles of wine for investment purposes involves valuable products that are sold mainly in auctions in London, New York, Chicago, and a few other cities. The number of lots and participants is very limited. Bidders can also take part in auctions by telephone—a very common occurrence in the wine sector. With few buyers, a physical presence at the auction can make the difference as the number of participants can be seen, which is an indicator of the interest of buyers in the good sold. Therefore, anyone who participates in the auction by telephone loses out on precious information and often ends up paying a higher price (Ginsburgh, 1998). Financial markets, by contrast, have millions of buyers participating in the online sales and purchases.

Basically, comparing the return and risk profiles of traditional financial assets and bottles of wine is like comparing apples and pears: they are both fruits, both give juice, but they are not the same thing. The comparison is further complicated by the different nature of wine which is a consumer good while stocks and bonds are investment assets. Consumer goods such as oil, copper, and meat are purchased primarily for consumption while investment assets such as gold and silver are purchased mainly for investment purposes. These two metals have multiple industrial and commercial uses and, therefore, a double value, but they are universally regarded as investment goods because there are a substantial number of people holding them for this second purpose. A high number of buyers for investment purposes ensures that there are no long-lasting opportunities for arbitrage. For consumer goods, however, this is not the case. The return on the physical possession of an asset (convenience yield) can keep a productive process active or exploit temporary local shortages of the goods (see Hull, 2009, chapter 5).

5.1.2 Investments in Winery Securities

While there is an abundance of studies on the opportunity to include bottles of wine in security portfolios, the scientific literature has completely ignored investments in shares of publicly listed wineries. The only exception is Baldi et al. (2010), who used a nonlinear cointegration model to study the long-term relationship between the price indices of winery shares (Global Wine Industry Share Price Indexes) and equity indices in five countries: France, United States, Chile, China, and Australia.[3] The presence of cointegration between different stock market indices indicates that, apart from short-term deviations from a common equilibrium, they move in the same direction in the long term (Masih and Masih, 1997; Patra and Poshakwale, 2008). In the presence of cointegration, the two indices move together, which reduces the power of diversification, while the absence of cointegration reduces risk by leaving the expected long-term return unchanged (Berument, Akdi, and Atakan 2005; Ratner, 1996). The presence of cointegration also implies a causal effect in at least one direction which allows the use of the short-term returns of an index to predict the movements of the other.

The results of the study by Baldi, Vandone, and Peri (2010) showed that, in the more mature markets—that is, France and the United States—there is Granger causality from the share index to the wine sector index and that the adjustment speed of the latter to the long-term equilibrium is lower than the equity index. This implies that deviations from the equilibrium of the wineries index last longer than those of the composite index. Investors, therefore, can make profits by anticipating short-term changes in the index of wine prices based on the movements of the composite index. In less mature markets like China and Chile, the two indices always present a nonlinear cointegration but this time with the same speed of adjustment to the long-term equilibrium.

5.2 Risk-Hedging Instruments

Wineries are exposed to a number of risks that influence the investor's utility and the expected return. The two most important factors are the variability of weather conditions and that of exchange rates due to the increasing share of exports in total production. These two risks can be managed ex ante or ex post. Reserves may be accumulated to tackle difficult times before damage actually occurs, thus reducing exposure to risk factors as far as possible (e.g., making irrigation systems or selecting clones of plants that are more resistant to pests) through insurance contracts and derivative instruments.[4] Insurance and derivatives can both be used as hedging instruments against risk, but they are different from a regulatory, accounting, fiscal, and legal point of view (World Bank, 2011, p.18). An insurance contract, moreover, guarantees an indemnity that is proportional to the damages actually suffered, conditional on their verification and postponed in time. A derivative, instead, may depend on the value of some underlying condition (the weather, the price of goods, or currencies) regardless of the actual damage suffered or the possession of the good. The ex post solutions consist in the request for support from the state when none of these measures have been taken.

5.2.1 The Benefits of Covering Risks

This section deals with the topic of risk coverage through the use of financial instruments. Covering against risk—as, for example, through the purchase of an insurance policy—means the inclusion of a new security in the portfolio at the same time as lowering both risk and the expected return. Risk is reduced because the yield on the policy is negatively correlated with at least one portfolio asset that is insured. At the same time, the expected return decreases as a result of the premium payable to the insurer in exchange for data collection and processing, administrative costs, the opportunity costs of holding reserves, and any compensation for damage. Taking out insurance therefore entails a trade-off between reducing risk on the one hand and maintaining the expected return on the other. The willingness to pay a premium to the insurer to reduce risk is a direct function of the investor's risk aversion.

The presence of an insurance and derivatives market at affordable prices can stimulate economic growth as individuals with greater risk aversion will invest in activities characterized by greater uncertainty (and therefore a higher yield) only if they can transfer the uncertainty onto third parties (Skees, Barnett, and Collier, 2008).[5] This point has often been used to advocate public intervention in favor of the insurance market, especially against natural disasters and catastrophic events. This, however, would only affect sectors subsidized by the state, draining resources from others and creating a phenomenon of displacement. Further, if support for the insurance market is not well organized, it can also generate strong inefficiencies favoring very risky investments—as, for example, when building is encouraged in developed countries in plains prone to the risk of flooding (Mileti, 1999) or when cultivation of crops that need a lot of water are encouraged in areas subject to drought (Skees, 2001).

5.2.2 Insurance Against Damage

Is it always possible to cover a risk by transferring it to a third party? The answer, unfortunately, is no. The scientific literature suggests five criteria for determining the insurability of a risk:[6] (1) the distribution of the event is known, or it is possible to calculate expected future losses; (2) the damages are observable; (3) the risk of adverse selection is limited; (4) the risk of moral hazard is limited; and (5) the extent of losses is not excessive.

Known distribution. The first is an actuarial condition. To predict expected damage, a circumstance must belong to a sufficiently homogeneous category of events that are subject to the same sources of risk and their distribution must be reliably estimated. According to the law of large numbers (Bernoulli, 1713), this requires an appropriate sample size whose quality, however, is not always the same. If losses are independent and identically distributed (IID), then the prediction is much simpler and more accurate and only a small sample is needed. The more the distribution moves away from the IID, the more observations are required because tail events become difficult to forecast. If the distribution approaches IID, the risk of catastrophic events with a large number of subjects affected by significant damage or even devastation decreases. A loss is considered catastrophic when it is unexpected and extraordinarily large compared with the amount of assets in the insured portfolio. Catastrophic losses have two properties: they are difficult to predict, and they are concentrated geographically. Hurricanes are less catastrophic than earthquakes because they occur more regularly and frequently and are easier to predict. Apart from the unpredictability of the type of event, the possibility of modeling the risk can also depend on the lack of databases with long and reliable time series.[7] The factors that determine an insurance premium are the average expected loss, the operating costs associated with the creation and management of the portfolio (insurance pool), reserves for unexpected losses, and the profit of the insurer. The first three are costs, and the fourth is a gain. If the distribution of events is known, then both the operating costs and the reserves necessary to deal with unexpected events decrease. The insurance of events that are difficult to predict may involve such high premiums as to discourage the applicant from covering against the risk.

Observable damage. The second insurance criterion is quite an obvious condition: if losses are not verifiable, the insured can declare greater damage than was actually suffered, which can prevent the market from even being set up. Further, the cost of measuring the damage must be reasonably limited; otherwise, the insurance premium rises.

Adverse selection. In the insurance sector, adverse selection occurs when the insurer cannot assess the degree of risk for the various subjects requiring coverage and is forced to apply a single premium to all. This can push the best customers out of the market, increasing the average risk of a portfolio and pushing the insurer to increase further the premiums in line with Akerlof's (1970) vicious circle, which has already been described. Insurers make enormous efforts to assess the risk associated with each customer so as to differentiate and personalize the premium, but sometimes this is difficult or even impossible.

Moral hazard. Moral hazard occurs when the insured intentionally causes a loss to obtain compensation, claims damages greater than those actually suffered, or reduces efforts to avoid ill-fated events (Rothschild and Stiglitz, 1976; Gollier, 2005). The absence of moral hazard implies that losses are defined, measurable, and accidental and are uninfluenced by the behavior of the insured. On the contrary, the presence of opportunistic behavior leads to the start of vicious circles.

No excessive losses. The last condition is related to the size of potential losses, which (if excessive) can make insurance by a single agent impractical. A terrorist attack with bacteriological weapons or a large-scale earthquake would cause losses in terms of lives and physical capital that no insurance company could compensate. Risk sharing can alleviate the problem, but the size of potential losses could make the accumulation of such big reserves necessary as to make the insurance premium unacceptable. Pollner (2001) pointed out how the natural catastrophes of the early 1990s (e.g., earthquakes and hurricanes) caused a sharp contraction in the insurance market, leading to increases in premiums of between 200 percent and 300 percent in the Caribbean.

An almost perfect example of insurable risk is the automotive market, characterized by the presence of a huge number of circulating vehicles (millions in each country) and a high number of accidents but relatively randomly distributed and limited damage (at most a few million euros or dollars for one accident). Losses are verifiable, although sometimes it can be difficult to distinguish previous damage from that of the accident. The problems of adverse selection and moral hazard are present but are mitigated by regular official vehicle inspections and the introduction of incentive mechanisms, such as points on a driver's license, the "bonus-malus" system, and black boxes in cars.

5.2.3 Weather Risk

Of the two main risks affecting viticulture, weather is undoubtedly more difficult to insure against. Skees, Barnett, and Collier (2008) underlined how agricultural insurance is one of the most difficult to develop since damage is not independent (geographic correlation) and there are marked information asymmetries between the insured and the insurer. There are two types of agricultural insurance:

1. *Multiple Peril Crop Insurance* (MPCI) is related to crop yield and was created and subsidized by the US government (Barnett, 2000; O'Boyle, 2018). If productivity (e.g., quintals or tonnes per hectare) is lower than the historical average of the insured land by a certain percentage (e.g., 50 percent or 70 percent), the farmer obtains compensation proportional to the missing gain (Skees and Barnett, 2004). Since the yield can depend on a number of variables, which range from climatic conditions to management, it is impossible to identify which factor(s) is responsible and to insure the harvest against one or more specific elements. For this reason, the insurance compensates the owner of the land if the yield falls below a preestablished threshold, regardless of the cause. This type of insurance is difficult to develop because of the obvious information asymmetry problems, the amount and accuracy of the necessary data, the premium that grows together with the number of risks covered, and the correlation between the damage of farms located in the regions affected by the same calamity. The empirical evidence presented by Hazell (1992) was based on seven countries[8] in the 1970s and 1980s and showed that the total compensation paid and administrative costs of MPCI far exceeded the value of the premiums collected (in all countries, the outflows were more than double the revenue). The author concluded that this model of risk coverage, even taking into account the social benefits, is economically unsustainable. In fact, it was maintained only through public subsidies, and over the years has been withdrawn or considerably reduced in many countries (Skees, Barnett, and Collier, 2008);
2. *Index insurance*.[9] In this case compensation is a function of an index that constitutes a proxy for the damage suffered by the individual producer and is provided by an independent third party (Barnett and Mahul, 2007). The two most important types of indexes are the average productivity of a certain area, which requires a great deal of data, and the climatic conditions (e.g., temperature, rain, humidity, wind) recorded at a particular weather station. This type of index insurance is easier to provide because long and reliable time series of meteorological data are also available for the least developed countries. The administrative costs are, in addition, very low because data does not have to be collected ex ante or damage measured in each individual farm ex post, thus eliminating the problems of adverse selection and moral hazard and making compensation faster. For this tool to be effective, the index and individual damage must, of course, be strongly correlated. The difference between the loss suffered and compensation constitutes the basis risk, which represents the greatest obstacle to the development of index insurance. Further, there is not enough data for an evaluation of the actuarial performance of these instruments at the moment, and the consequences of climate change raise questions about the possibility of developing and managing them (Hellmuth et al., 2009).

In any case, derivatives on weather conditions exist and are strongly supported by both the World Bank and the International Fund for Agricultural Development (IFAD) as instruments of risk coverage, especially for farmers in developing countries.[10] With particular reference to the wine sector, three different studies have developed price models for weather derivatives and have concluded that these tools can offer valid coverage against weather risks (see Turvey, Weersink, and Chiang [2006] and Cyr and Kusy [2007] for an application to the Ontario ice-wine; and Zara [2010] for a simulation on the Controlled Designation of Origin [DOC] Oltrepò Pavese Bonarda).

5.2.4 Currency Risk

Exporting and importing companies are also exposed to currency risk. Let us imagine a European winery that signs a contract (at time $t = 0$) with a US importer for the delivery of one thousand bottles of wine within six months (at time $t = T$) at the agreed price of €5 for each unit. At time $t = 0$, the exchange rate of dollars to euros ($/€) is 1.30. In the absence of currency fluctuations, the importer will have to pay the sum of $1{,}000 \times 5 \times 1.30 = \$6{,}500$ at time $t = T$. If, however, the exchange rate increases to 1.40, the company will have to pay $1{,}000 \times 5 \times 1.40 = \$\ 7{,}000$. To cover against risk, the importer can adopt various strategies (see Björk, 1998, pp. 1–3), such as the following two examples.

1. Buy €5,000 today for the price of $6,500 and keep it in a checking account for six months. This eliminates the currency risk completely. The problem is that this blocks a substantial amount of money for six months or that the company may not even have this sum available.
2. A second and more sophisticated solution consists in buying a European call option for €5,000 with a strike price of K $/€ at time $t = 0$ to be exercised eventually at time $t = T$. The currency option gives the purchaser the right, but not the obligation, to buy €5,000 at the predetermined exchange rate K in six months' time, and this will only happen if the dollar has devalued in the meanwhile. For example, the option confers the right to buy €5,000 at the $/€ rate of 1.30. If during the six months the rate increases (e.g., 1.40), then at time $t = T$ the option is exercised and the company pays $5{,}000 \times 1.30 = \$6{,}500$ to buy €5,000, which at the current rate is worth $5{,}000 \times 1.40 = \$7{,}000$. If, on the contrary, the rate remains unchanged or decreases, the option is not exercised. From a conceptual point of view, currency options do not differ much from index insurance, in which the premium is paid only if an indicator exceeds or falls below a certain threshold.

The options therefore protect companies from price decreases or increases above a preestablished threshold and may have any type of goods or securities traded on the market—from currencies to cereals and so on—as underlying securities. European options differ from American options because the right to buy or sell at the preestablished price can only be exercised in $t = T$ and not at any time as in the US options.

Derivatives in general can be used to pursue two opposite objectives—namely, speculation and risk hedging. They can be traded on the stock market, in which case they have standardized characteristics, or informally and unregulated (over the counter, or OTC), adapting the instrument to the needs of the individual customer. According to data released by the Bank for International Settlements, there were $96.5 trillion of derivatives traded on the regulated market and $640 trillion on the OTC market still outstanding in the first half of 2019.[11] Most OTC securities consist of derivatives on interest rates (interest rate contracts, 81.8 percent), but those on exchange rates also play a significant role (foreign exchange contracts, 15.4 percent).[12]

Appendix 5.1: Notions of Investment Theory

When faced with investment choices,[13] a person's temperament can take on infinite nuances ranging between the two extremes of a risk-averse individual and a risk lover, with the figure of a risk-neutral individual somewhere in the middle. The first case constitutes normality:[14] one of the basic principles of finance is that investors facing a higher level of risk demand greater returns. The difference between the performance of two investments, one with and one without uncertainty, is called "risk premium." The second case is a gambler who, on the contrary, enjoys uncertainty. The third profile is a person who is indifferent to risk and considers only the expected return in investment choices. A gamble, however, must not be confused with speculation: in a gamble the person derives pleasure from the random situation, even if this does not involve any increase in the expected return, whereas in speculation the investor is willing to accept a higher level of risk only in exchange for an adequate expected return. Aversion to risk and speculation are, therefore, not incompatible.

A utility function which is widely used in literature and by the Association of Investment Management and Research formalizes and summarizes these different profiles with the following utility function:

$$U = E(r) - 0.005A\sigma^2, \tag{5.1}$$

where U represents the utility of the individual, $E(r)$ and σ^2 the expected yield and the variance of the investment respectively, and A the index of subjective aversion to risk. The number 0.005 is a convention to scale the standard deviation σ and to express it as a percentage (e.g., 20 percent) instead of in decimal numbers (0.20), as with the expected return. Equation 5.1 represents the three types of investors. Assigning a positive (or negative) value to A describes the behavior of the subject who is averse to risk (or a risk lover) while utility coincides with the simple expected return when A is equal to zero (indifferent). Graphically the indifference curves for the risk-averse subject are positively inclined and have a rising slope (figure 5.A.1). In this case p refers to a single security, but the same concept applies to a portfolio.

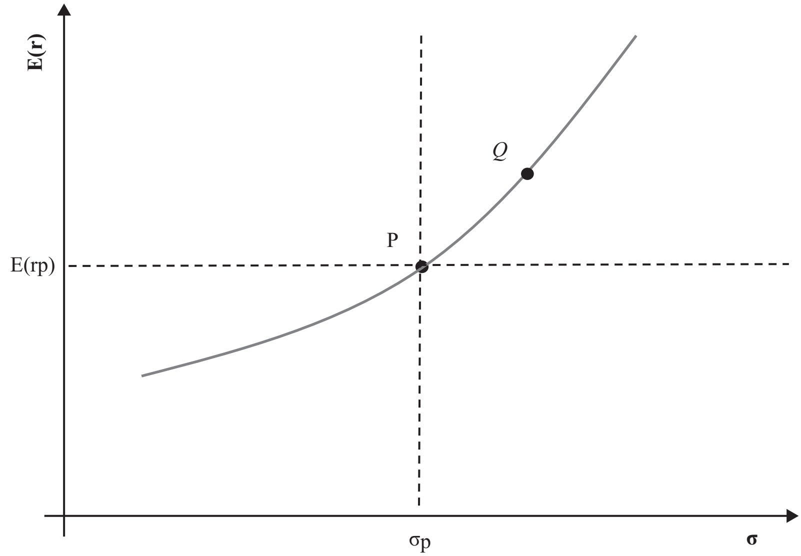

Figure 5.A.1
The indifference curve.

If we consider investment p, which has an expected return $E(r_p)$ and a standard deviation σ_p, the expected utility is $U(p)$. All the investments placed top left of point P (quadrant II) have higher expected returns and/or lower risk and are therefore preferred in accordance with the mean-variance criterion. The opposite is true of investments placed in the lower right corner (quadrant IV) while in the other two areas utility can be greater than, equal to, or less than point P. From this simple explanation, therefore, we can see the importance of not limiting the comparison of two alternative investments simply to the expected return and, as a consequence, the need to consider the degree of risk.

When we move from considering a single security to analyzing the risk of an entire portfolio, we have to take into consideration the interactions that exist between the different investments. A security that has returns negatively correlated with other portfolio assets can be used as a risk-hedging instrument in the same way as an insurance policy. In finance there are two sources of risk: (1) market risk, which is attributable to factors such as the performance of the economy and the interest and exchange rates, affects the returns of all companies and, as a consequence, is not diversifiable; and (2) firm-specific or idiosyncratic risk, which instead concerns the management of a single company. If the returns on the securities do not have a perfect positive correlation ($\rho < 1$), diversification by adding securities to the portfolio reduces the firm-specific risk, but market risk cannot be eliminated. Figure 5.A.2

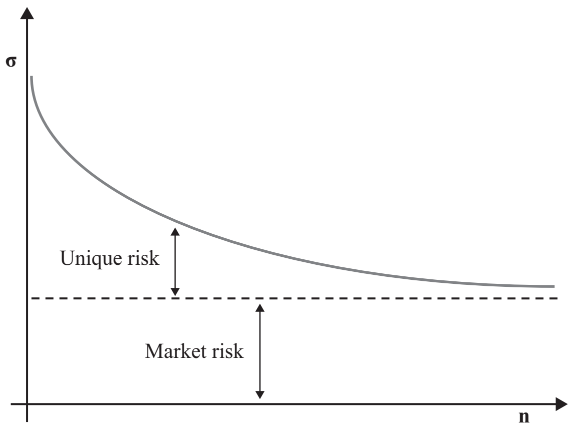

Figure 5.A.2
Portfolio risk and number of assets.

shows the benefits of diversification obtained by adding identical shares (e.g., units) of different securities. This example proposes a very simple technique for risk diversification that assigns the same weight to each security in the portfolio.

Let us now analyze the case in which the weight varies, and consider only two securities for the sake of simplicity. The return on the portfolio is given by the average of the returns of the individual investments *r(s)* weighted for its respective share *w(s)* with $w_1 + w_2 = 1$:

(5.2) $$r_p = \sum_s \mathrm{w(s)}\, r(s).$$

The variance is given by the sum of the variances σ^2 of the two weighted securities for the squares of the respective weights w plus a component that includes the covariance between the two returns:

(5.3) $$\sigma_p^2 = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2Cov(r_1, r_2),$$

where the latter is given by

(5.4) $$Cov(r_1, r_2) = \sum_s \Pr(s)[r_1(s) - E(r_1)]\,[r_2(s) - E(r_2)],$$

where *s* represents a possible scenario. A positive covariance implies that the yields of the two securities move on average in the same direction (positive correlation) and vice versa (negative correlation). From this simple formula we can immediately understand the role played by covariance in determining portfolio risk: a positive covariance between the two securities increases portfolio risk while a negative covariance reduces it. In the latter case an instrument is considered a hedge, following the old proverb "do not put all your eggs in the same basket," and therefore its function is similar to that of an insurance.

Efficient diversification involves trying to minimize risk for any given expected level of return by buying shares that are not necessarily the same as the securities characterized by negative correlations. Now, to what extent can the portfolio risk decrease? For analytical simplicity, only two securities will be considered (1 and 2),[15] but the results also hold for portfolios with a large number of securities. Since

$$Cov(r_1, r_2) = \rho_{12}\sigma_1\sigma_2, \tag{5.5}$$

if the two securities have a perfect negative correlation ($\rho = -1$), equation 5.3 becomes:

$$\sigma_p^2 = (w_1\sigma_1 - w_2\sigma_2)^2 \,. \tag{5.6}$$

At this point it is sufficient to choose portfolio shares w_1 and w_2 so that the portfolio standard deviation is zero (no risk):

$$w_1\sigma_1 - w_2\sigma_2 = 0. \tag{5.7}$$

The portfolio securities that solve this equation by eliminating risk are:

$$w_1 = \frac{\sigma_2}{\sigma_1 + \sigma_2}, \text{ and} \tag{5.8}$$

$$w_2 = 1 - w_1 = \frac{\sigma_1}{\sigma_1 + \sigma_2} \,. \tag{5.9}$$

If short sales are allowed, the same results can be obtained in the presence of a perfectly positive correlation ($\rho = 1$). Perfectly positive and negative correlations are purely theoretical; in real life they are much lower. In any case, the purchase of securities with $-1 < \rho < 1$ constitutes a valid alternative to those without risk since they allow a reduction in portfolio variance at the same time as achieving higher returns, thus moving the efficient frontier to the upper left (figure 5.A.3).

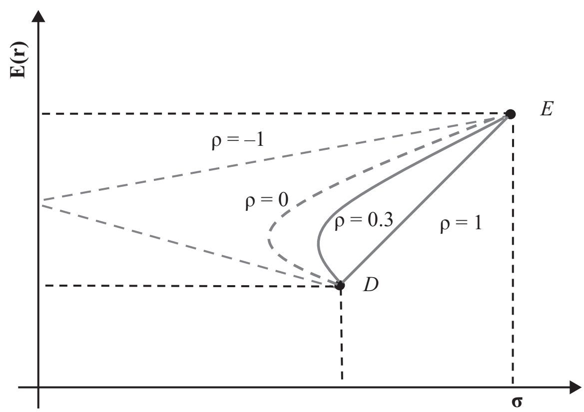

Figure 5.A.3
Portfolio expected return and standard deviation.

From an operational point of view, the investor has to take three separate steps to choose the best portfolio (figure 5.A.4). The first, as formalized by Markowitz (1952), consists in the identification of the efficient frontier, given by the set of portfolios that minimizes the variance for each given expected level of return through diversification, and the selection of securities characterized by negative covariances. The second involves the definition of the highest capital allocation line (CAL). This line, which represents combinations of risk and return on portfolios, including one part of risk-free securities and one of risky securities, has the maximum slope when it is tangent to the efficient frontier. This point is called the "optimal portfolio" since it maximizes the expected return per unit of risk. All points that are placed on the CAL maximize the yield expected per unit of risk. The third step consists in deciding at which point the investor wants to position themselves and therefore the risk profile. Once the CAL has been selected, individuals will try to maximize their utility, which depends on the expected performance and portfolio risk, in relation to their risk aversion. People with a higher degree of aversion will choose a less aggressive portfolio, positioning themselves on the left side of the line and vice versa.

If we now consider individual securities, what kind of performance should we expect? The CAPM proposed by Sharpe (1964) and developed by Lintner (1965) and Mossin (1966) is an equilibrium model of the financial market that establishes a relationship between the expected return of a security and its riskiness. The hypotheses underlying the model are as follows:

1. "atomistic" investors: each investor holds too few securities to influence the market, so they are price-takers;
2. investment plans concern only a single period, even if this short-sightedness is a suboptimal strategy;
3. investments only concern securities traded in the market (e.g., shares, bonds, and debt securities);

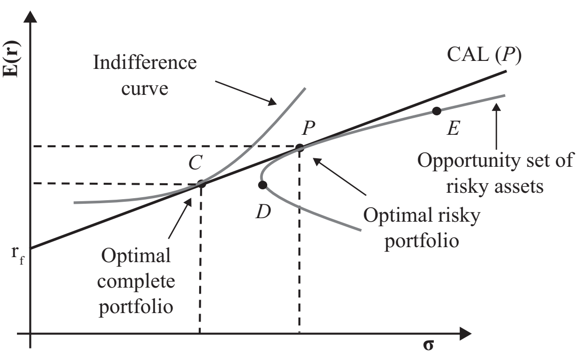

Figure 5.A.4
Identification of the optimal portfolio.

4. there are no taxes or transaction costs;
5. investors aim to maximize the relationship of expected return on risk (mean-variance optimizers) and therefore use Markowitz's (1952) portfolio selection model;
6. expectations are homogeneous. Since all investors use Markowitz's (1952) model with exactly the same predictions about the expected return on securities, all obtain the same efficient frontier and the same optimal portfolio.

If all these conditions are satisfied, it follows that (a) all investors hold a portfolio of risky securities that replicates the market portfolio, (b) the market portfolio is on the efficient frontier at a tangent to the CAL, which is therefore maximized, and (c) the risk premium of each security is a function of the risk premium of the market portfolio and of the beta coefficient, measuring to what extent the security and the market move in the same direction:

$$\beta_i = \frac{Cov(r_i, r_M)}{\sigma_M^2}, \tag{5.10}$$

while the risk premium of the single security that can be expected is

$$E(r_i) - r_f = \frac{Cov(r_i, r_M)}{\sigma_M^2}[E(r_M) - r_f] = \beta_i[E(r_M) - r_f]. \tag{5.11}$$

This expression is often represented only in terms of expected performance:

$$E(r_i) = r_f + \beta_i[\mathrm{E}(r_M) - r_f]. \tag{5.12}$$

The expected return on an asset is the rate on risk-free securities plus the risk premium of the market portfolio multiplied by beta, which measures the riskiness of the security. With $\beta = 1$ we have an expected return that is perfectly correlated with the market portfolio, and thus there should be the same risk premium as for a market portfolio. A security that has $\beta > 1$ is considered aggressive since its performance amplifies fluctuations in the market. A security that has $\beta < 1$ is considered defensive as it may be used as a hedging instrument. Since there is no free lunch, this insurance function involves a cost to the investor which leads to a lower expected return.

The CAPM is a theoretical model based on very restrictive and unrealistic assumptions. In practice, there are big investors (for example, investment funds like Black Rock) capable of influencing markets, and there are long-term strategies, taxes, transaction costs, uneven expectations, and so on. Moreover, the expected returns are not observable, and we have to know the composition of the real portfolio market and not that of its approximation as in the S&P500 Index to be able to verify the model correctly (Roll, 1977). It is, nevertheless, often used to obtain rough indications about whether it is desirable to buy securities. The security market line (SML) (figure 5.A.5) relates the expected and beta yield. When the beta yield is equal to

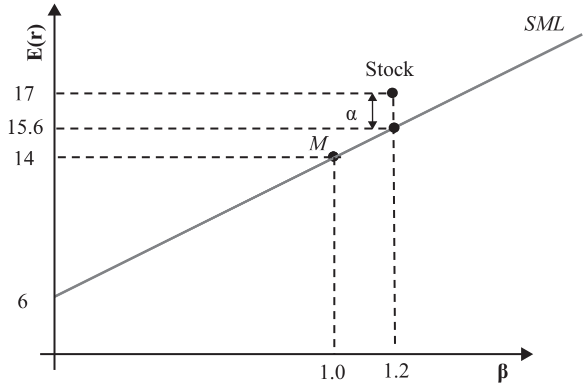

Figure 5.A.5
SML and an asset with positive α.

zero, the CAPM does not provide for any risk premium; whereas when it is equal to one it provides for the risk premium of the market portfolio. When the expected return (positive alpha) on securities that are above the SML is too high, these securities will have too low a price. Instead, the securities that are below (negative alpha) will have too low an expected return, and therefore these securities are too expensive. The estimation of the alpha coefficient can, therefore, evaluate the presence of abnormal returns while the beta coefficient is the risk profile of securities (aggressive, neutral, or defensive).

Since expected returns are not observable, the following single index model expressed in terms of excess return on the rate of risk-free securities ($R_i = r_i - r_f$ and $R_M = R_M - R_f$) can be estimated:

$$R_i = \alpha_i + \beta_i R_M + \varepsilon_i, \tag{5.13}$$

where ε_i is the specific risk linked to the single security. $Cov(R_i, \varepsilon_i)$ is zero while the covariance between R_i and R_M is

$$Cov(R_i, R_M) = Cov(\beta_i R_M + \varepsilon_i, R_M) = \beta_i Cov(R_M, R_M) + Cov(\varepsilon_i, R_M) = \beta_i \sigma_M^2, \tag{5.14}$$

in which alpha disappears because it is constant. It follows that the coefficient beta is equal to

$$\beta_i = \frac{Cov(R_i, R_M)}{\sigma_M^2}. \tag{5.15}$$

The beta coefficient obtained by estimating this single index model is identical to that of the CAPM with expected returns, with the exception of the market portfolio that is replaced by an observable market index. More recently Fama and French (1992, 1993, 1995) have extended the CAPM by introducing two additional risk factors based on the widespread belief that securities of small companies with a strong book-to-market ratio present higher returns than expected with the Sharpe (1964), Lintner (1965), and Mossin (1966) model. The two risk factors added to the model are small minus big (SMB) and high minus low (HML).[16] The first is given by the difference between the expected returns of portfolios of small capitalization stocks and large capitalization stocks while the second is given by the difference between the expected returns of portfolios of securities with a strong book-to-market ratio and portfolios of securities with a low book-to-market ratio:

$$E(r_i) - r_f = a_i + b_i\,[E(r_m) - r_f] + s_i E(SMB) + h_i E(HML). \tag{5.16}$$

If the price of the securities is correctly established, the coefficient *a* should be zero. As for the CAPM, an econometric estimate can once again be made with the following model:

$$r_i - r_f = a_i + b_i(r_M - r_f) + s_i E(SMB) + h_i E(HML) + \varepsilon_i. \tag{5.17}$$

The authors verified the model using US stock data and found that the inclusion of two additional risk factors increases the explained variance (R2) from 70 percent to over 90 percent. Fama and French's model, as indeed the CAPM, can assess whether wine investments guarantee too high or too low returns compared with the model (and therefore the price is too low or too high, respectively) as well as their correlation with the specific risk factors.