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Abstract

The absolute and relative impact of current quality and reputation variables on consumer decisions are examined using data from the market for Bordeaux wine. The estimates indicate that a model of consumer decision making which incorporates information on reputation (past quality) and collective reputation (average group quality) rejects alternative models that include current quality. The results also indicate that reputation has a large impact on the willingness to pay of consumers, that long term reputation is considerably more important than short term quality movements, and that consumers react slowly to changes in product quality. Collective reputation is shown to have an impact on consumer willingness to pay that is as large as that of individual firm reputation. If reputation and collective reputation effects are ignored, the estimated impact of current quality and short term changes in quality on consumer behaviour are overstated.

I. Introduction

Many empirical studies have found that price is not a good indicator of product quality. In a review of 90 studies, Zeithaml (1988) finds there is only "mixed evidence" of a positive correlation between price and quality while the 13 studies surveyed by Geistfeld (1988) report a mean Spearman coefficient for the price-quality correlation of only .19. Geistfeld (1988) argues that the low correlation between price and quality implies that markets are not operating efficiently. Alternative explanations for the low price-quality correlation stem from the costs to consumers of gathering product information. Tellis and Wernerfelt (1987) find that goods for which some information is easily available by inspection exhibit a higher price-quality correlation. Riesz (1978, 1979), Gerstner (1985), Tellis and Wernerfelt (1987), and Hanf and von Wersebe (1994) find that the correspondence between price and quality is stronger for goods for which the cost of being uninformed is greater (durable goods). Ratchford and Gupta (1990) show that a low price-quality correlation is consistent with efficient consumer behaviour if there are search costs.

If consumers face costs of gathering information on product quality, they may rely on the quality reputation of firms to predict current quality. In this case, prices will reflect the quality of output produced by firms in the past rather than current quality. This reputation effect is likely to be particularly important for "experience" goods — many manufactured goods, services and most packaged goods — for which quality can be ascertained only after purchase and use. The importance of reputation in determining consumers' willingness to pay for a good has been recognized in the theoretical literature (Klein & Leffler, 1981; Shapiro, 1983; Allen, 1984; Rogerson, 1987). However, the size of these reputation effects, and their significance relative to the role of current quality, have received little attention in the empirical literature.

This paper provides an empirical analysis of the extent to which consumers use reputation and current quality indicators when making purchase decisions. It does this by relating prices to the information that is available to consumers. If consumers have information on current product quality, the price they are willing to pay for a product will depend on this current quality information. When consumers do not know current quality, but can observe reputation indicators which they use to form perceptions of current quality, price will reflect the value to consumers of these reputation indicator variables rather than current quality.

In order to analyze the type of information used by consumers when making consumption decisions, five models of price determination are estimated and compared. These models differ only with respect to the quality-reputation information available to consumers. In the *full-information* model, consumers have complete information on quality and, thus, current quality is the only quality-reputation factor that influences prices. The *reputation* model assumes that information on current quality is not available or is too costly to obtain and, as a result, the price of a firm's product depends on its reputation for quality, not its current quality. In the *collective reputation* model, consumers do not have information on either the current quality or reputation of an individual firm. As a result, they base their forecast of the quality of the good produced by an individual firm on the average quality of the goods produced by a group of firms with which the individual firm is identified. The final two models employ combinations of the information sets associated with these three models.

The five models described above are estimated using data from the market for Bordeaux wine. While this means that the results are based on data for only one type of good, the data set includes a large number of observations. This is in contrast to most studies of the price-quality relationship which contain relatively few observations on each type of good, such as studies which use data from *Consumer Reports* (Oxenfelt, 1950; Friedman, 1967; Sproles, 1977; Riesz, 1978, 1979; Geistfeld, 1982; Gerstner, 1985; Curry, 1985) or from similar sources such as *Runner's World* (Archibald, Haulman & Moody, 1983), *Canadian Consumer* (Bodell, Kerton & Schuster, 1986) or the German consumer magazine *Test* and the Danish magazine *Råd og Resultater* (Hjorth-Anderson, 1991). Furthermore, as suggested by Geistfeld (1988), the use of data from another source, as is done here, may be useful in and of itself. Several of the other advantages of this data will be discussed more fully below.

The rest of the paper is organized as follows. The balance of this section reviews the empirical literature on reputation and discusses the characteristics of the Bordeaux wine industry. Section II outlines the theoretical methodology underlying the estimating equations. A description of the data, and a discussion of the advantages of the data set used, are presented in Section III. The empirical specification is described in Section IV. Section V provides an analysis of the empirical results and Section VI gives a brief summary and concluding comments.

The Empirical Literature on Reputation

In contrast to the empirical literature on price-quality correlations, the empirical reputation literature is extremely limited. Jarrell and Peltzman (1985) and Borenstein and Zimmerman (1988) analyze the importance of firm reputation by quantifying the impact on shareholder wealth of product recalls and airline crashes, respectively. Results in Mannering and Winston (1985, 1991) suggest a link, possibly a lagged reputation effect, between the decline in the quality of GM products and the fall in demand for GM cars in the 1980s. Thomas (1993) includes a previous period performance measure for the household goods motor carrier industry in a hedonic price regression, although not explicitly as a proxy for firm reputation. While these studies all examine reputation effects to some extent, none explicitly relates reputation to product prices or compares the effect of reputation and current quality on consumer behaviour.

There is also only a small empirical literature that analyzes the importance of collective reputation. Jarrell and Peltzman and Borenstein and Zimmerman examine, respectively, whether recalls or airplane crashes associated with one firm have an impact on the wealth of the shareholders of other firms in the same industry. Although Borenstein and Zimmerman find no evidence of a collective reputation effect of this type, Jarrell and Peltzman find that a recall by one US automobile or drug firm reduces its US competitors' share value, a result which suggests the possible existence of a collective reputation effect. Both studies examine relatively narrow quality indicators (recalls and crashes) and neither analyzes the impact of collective reputation on product prices.

The brand loyalty literature examines concepts similar to reputation and collective reputation. However, this literature differs from the reputation literature in that it concentrates on explaining repeat purchases, rather than prices, and examines many factors other than past quality (the number of previous purchases of the product, the cost of switching brands, brand-specific user skills and advertising) which lead customers to re-purchase specific products (Mannering & Winston, 1985, 1991). As well, brand loyalty is associated with products produced by a single firm that can internalize brand benefits. In contrast, collective reputation effects are associated with firms that are not directly related, and so imply much different information transmission and behaviour than does brand loyalty.

The Bordeaux Wine Industry

The market for red Bordeaux wine is particularly appropriate for an empirical analysis of the relationship between price, quality and reputation. For example, the Bordeaux wine industry is relatively stable in the sense that it is not rapidly expanding or contracting, there are no large changes taking place in the technology of wine making, and producers are not significantly altering the form of their existing product. In addition, most producers make only one or two wines. These factors imply that the relationship between price, quality and reputation is unlikely to be obscured by the effects of technological change, product interactions in multi-product firms or the introduction of new products or product designs.

Another advantage of Bordeaux red wine industry data is that Bordeaux wines, although differentiated products, differ in only a relatively small number of characteristics. The wines come from a fairly small region, are packaged in identical bottles (although their labels differ) and can be made from only five grape varieties. Additional regulations control grape growing methods, alcoholic strength, maximum allowable yields and the delimination of vineyards. Thus, the measurement of quality is not likely to be obscured by difficult to quantify aesthetic or design features, post-purchase repairs and services, or a large number of models and options, factors which are typically important in analyses of other consumer goods such as automobiles and computers.

Although weather and soil are important determinants of wine quality, many of the factors which determine the quality of a wine are under the direct control of the wine producer. For example, the producer must decide which grape varieties to grow; the extent of pruning; when to pick the grapes; whether to sort the grapes by hand and the basis on which to reject grapes; whether the wine will be fermented in oak, cement or stainless steel vats; how extensively to press the grapes following fermentation; the quantity and type of new oak barrels to use and the length of time to keep the wine in the barrels; and the extent to which the wine is filtered and clarified. Most of these decisions are made years before the wine is released. As a consequence, although quality depends on the actions of producers, it is pre-determined with respect to price and should not be contemporaneously correlated with the errors in the price equation.

Many of the wines of Bordeaux are produced in sufficient quantities to be widely available, the number of wine producing firms in Bordeaux is quite large, and there are no dominant firms in terms of production. As a result, the level of market prices does not depend significantly on the quantity produced by any single firm. In addition, the price of a bottle of Bordeaux wine (an average of $25.10 in 1985 U.S. dollars in our data set) is neither too low to make its purchase unimportant nor too high to be of critical importance to consumers.

II. The Theoretical Background

Since prices reflect the quality and reputation information used by consumers, it is necessary to specify a model of price determination that incorporates quality and reputation effects. An obvious starting point is the hedonic model of differentiated product price determination developed by Rosen (1974). In Rosen's model, each good is described by a vector of observable characteristics, **z**. The interaction of consumer demand functions and firm supply functions determines the price of each product as a function, P(**z**), of these characteristics. A subset of the elements of **z** represents the quality information available to and used by consumers. Therefore, the specification of the price equation will differ depending on whether consumers use current quality information, lagged quality information, or group quality information when making their purchase decisions.

The Full-Information Model

If consumers have freely available or low cost information on product quality, the **z** vector of characteristics which enters the price function, P(**z**), will include a measure of current quality as one of its elements. Since reputation variables (based on lagged quality) provide no additional quality information when current quality is known, consumers will not utilize reputation information when making their consumption decisions in this case. As a consequence, past quality (reputation) will have no impact on current prices and the output price of each firm i can be described by the function:

$$P_{it} = P(\tilde{\mathbf{z}}_{it}, Q_{it}), \tag{1}$$

where Q_{it} = the quality of the good produced by firm i at time t,

$\tilde{\mathbf{z}}_{it}$ = a vector of product characteristics, at time t, other than quality and reputation variables.

The Reputation Model

For many consumer goods, product quality is imperfectly observable prior to purchase and can only be accurately determined through use. If these "experience goods" are not frequently purchased, and if full information on product quality is not available to consumers or is costly to acquire, the price equation associated with the full-information model, equation (1) above, is inappropriate. In the absence of information on current quality, consumer demand will depend, at least in part, on predictions by consumers of product quality. The quality reputation of firms is one of the principal types of information consumers are likely to use when making these predictions. In this case, the price of each good will depend on a vector of variables reflecting the reputation for quality of the firm producing the good, $\mathbf{R}_{it}$ (along with $\tilde{\mathbf{z}}_{it}$):

$$P_{it} = P(\tilde{\mathbf{z}}_{it}, \mathbf{R}_{it}). \tag{2}$$

Theoretical models which analyze the role of firm reputation have been developed by Klein and Leffler (1981), Shapiro (1983), Allen (1984) and Rogerson (1987). In these models, a firm's reputation is assumed to depend principally on the quality of its past output. Shapiro, for example, considers reputation functions which equate reputation with one period lagged quality, Q_{it-1}, as well as more general functions in which a firm's current reputation for quality depends on both its lagged reputation and its lagged quality. This latter specification is consistent with consumers altering their assessment of a firm's reputation only gradually (perhaps because lagged quality information is initially only imperfectly observed). The key characteristic of these specifications is that each firm's reputation for quality is a function only of its past quality. It follows that price will be a function of lagged quality as well.

The Collective Reputation Model

The two models described above depend on consumers observing the current or lagged quality of the goods produced by individual firms. For some industries, particularly those with a large number of producers, it may be unrealistic to assume that either firm specific current or lagged quality information is easily available. In these industries, even though consumers are interested in the output quality of individual firms, it may only be possible (or cheaper) for them to acquire information on the quality reputation of a group of firms with which the firm producing the good being evaluated can be identified. This group information could then be used to predict or proxy the product quality of the individual firm. For example, in the automobile industry, consumers' expectations of the quality of a Japanese car may depend on the quality reputation of all Japanese cars (Ettenson, Gaeth & Wagner, 1988). In the wine industry, consumer expectations of the quality of wine produced by an individual winery may depend on the current or past average quality of all wines from the same vintage or region. Tirole (1996) develops a theoretical framework that takes a similar approach while Rasmusen (1989) discusses the related static concept of "teams".

If consumers predict individual firm quality on the basis of the quality reputation of a group of firms with which the individual firm is identified, the price function will include indicators of the collective reputation of this group of firms, rather than the current or lagged quality of the individual firm. That is, the price function will take the form:

$$P_{it} = P(\mathbf{z}_{it}, \bar{\mathbf{R}}_{it}), \quad (3)$$

where $\bar{\mathbf{R}}_{it}$ represents a vector of collective reputation indicators associated with the group of firms with which consumers identify firm i.

Two Extended Models

It is possible that the consumer information sets associated with the full-information and reputation models described above are too restrictive. For example, when consumers possess information on lagged quality, but not current quality, as in the reputation model, they may use collective reputation indicators to improve their forecasts of current quality. As well, even if consumers have complete current quality information, collective reputation indicator variables may affect their demand for different products because goods from some regions or countries may have snob appeal or names which are easy to pronounce. For example, Kramer (1994) argues that French wines with "a pronounceable French name" will be more successful in the U.S. market, and Berger (1994) suggests that, because "Chardonnay is easier to pronounce than Sauvignon Blanc," a Sauvignon Blanc wine will sell for a lower price than a Chardonnay of similar quality. Since consumers can easily observe many collective reputation indicators, such as nationality or region of origin, this information may have an impact on consumers' demand, and thus on price, in both the reputation and full-information models.

The incorporation of the vector of collective reputation variables in the full-information and reputation models yields the *extended full-information* and *extended reputation* models, respectively:

$$P_{it} = P(\tilde{z}_{it}, Q_{it}, \bar{R}_{it}), \tag{4}$$

$$P_{it} = P(\tilde{z}_{it}, R_{it}, \bar{R}_{it}). \tag{5}$$

Note that the full-information model, equation (1) above, is nested in (that is, a special case of) the extended full-information model, equation (4); the reputation model, equation (2), is nested in the extended reputation model, equation (5); and the collective reputation model, equation (3), is nested in both equations (4) and (5).

III. The Data

The data set consists of 559 observations on 196 different red wines from the five Bordeaux vintages (harvest years) of 1987 through 1991, although lagged quality data from the 1985 and 1986 vintages are also employed. For some of these wines current quality and price data are only available for a single year while for others the data set includes observations from all five vintages. The number of data points corresponding to each vintage varied from a low of 54 for 1987 to a high of 151 for both 1989 and 1990. Appendix I provides a detailed description of the data and data sources while data summary statistics are given in Appendix II.

Many hedonic price regressions incorporate several descriptive variables to proxy the quality of a product. For example, Kwoka (1992) uses automobile length and weight as proxies for quality while Thomas (1993) proxies the service intensity of household goods carriers with the number of man-days allocated by a carrier to each shipment. There are two problems with this type of approach. First, the products concerned are often technical and complicated and it is not clear whether the proxy variables reflect all the important characteristics of the good. Second, it may be difficult to draw definite conclusions when, as is often the case, the proxy variables used are highly multicollinear (Arguea & Hsiao, 1993).

The current study avoids these problems by employing a relatively finely gradated objective quality index. Data on this quality measure comes from the annual "Bordeaux" issue of the *Wine Spectator*, the largest circulation U.S. wine magazine, as well as from Shanken (1993). The data set includes every wine listed in the "Bordeaux" issue for which a price is reported (most of the wines) and for which two previous annual tastings by *Wine Spectator*, as well as average production information, are available. *Wine Spectator* evaluates a large number of Bordeaux wines and these are fairly representative of the Bordeaux wines available. For example, the data set includes observations on 54 of 61 of the producers included in the 1855 classification of Médoc wines and 143 of the 275 wines that belong to some type of "quality" classification.

The wine quality index (**Q**) reported in *Wine Spectator* rises by unit intervals from a minimum of 50 to a maximum of 100 and takes into account factors such as a wine's colour, aroma, flavour, balance, complexity and aging potential. Robert Parker, the developer of the "100 point scale", argues that "wine is no different from any consumer product. There are specific standards of quality that full-time wine professionals recognize." (Quoted in Robinson, 1994, 706-7.)[1] The quality rankings are the result of blind tastings and much of the tasting of the wine included in the sample was conducted by the same tasters.[2]

The price (**P**) used as the dependent variable in all the regressions below is the per bottle price in the U.S. (the U.S. retail price provided by *Wine Spectator* at the time of the "Bordeaux" issue) divided by the U.S. CPI so that all prices are in constant 1985 U.S. dollars. These prices varied considerably across the wines in the data set (from $6.78 to $302.56). This range is far greater than in most studies which use data from *Consumer Reports* and similar sources. For example, Hjorth-Andersen (1991) uses test data on 452 products and the average ratio of the maximum to minimum price for each commodity is approximately three. Most of the data used to represent non-quality and non-reputation characteristics of the wine in the sample (the $\tilde{z}_{it}$ variables) can be found in *Bordeaux* by Robert Parker (Parker, 1991).

The data from *Wine Spectator* have several characteristics which make it preferable to data from other sources. The "100 point scale" allows for finer quality differences than in most price-quality studies, many of which use *Consumer Reports* rankings that are based on a five-point scale. Furthermore, the data set provides both quality rankings and U.S. prices for each wine, and includes a large number and variety of different wines. Finally, the tastings on which the quality rankings are based take place at the same time each year, at approximately the time the wine is released, and the quality and price data are essentially contemporaneous.

There is a large literature that relates advertising to firm quality and price (Murdock & White, 1985; Parker, 1995). The data used below do not include information on advertising by different Bordeaux wineries. However, advertising may not be important since most of the firms included in the data set are small and evidence suggests that direct advertising by these firms in the U.S. is insignificant. For example, none of the firms in the sample advertise in *Wine Spectator* (although employees and owners of the firms do make themselves available for interviews). Thus, advertising expenditures are not expected to have an important impact on, or obscure, the price-quality relationship.

IV. Empirical Specification

Determining whether consumers rely on quality, reputation or collective reputation information involves estimating, and then comparing, the price equations associated with the five models described in Section II above. This section describes the variables used to represent individual and collective reputation, as well as the variables used to capture the non-quality and non-reputation characteristics of wine (the elements of $\tilde{z}$). The methodology used to select the functional form of the estimating equations is outlined at the end of the section.

Reputation and Collective Reputation Indicators

In order to estimate the reputation and collective reputation models, it is necessary to specify variables that reflect firm reputation and collective reputation in the Bordeaux wine industry. The vector of variables representing individual firm reputation, $\mathbf{R}_{it}$, consists of the first and second lags of the summary quality index ($\mathbf{Q}_{-1}/\mathbf{V}_{-1}$, $\mathbf{Q}_{-2}/\mathbf{V}_{-2}$), where these are divided by the *Wine Spectator* overall quality rating for each vintage to normalize for differences across vintages, as well as indicators of the longer term reputation of each firm. These longer term reputation indicators are five zero-one dummy variables based on a classification of Bordeaux wine producers by Parker (1991). This classification allocates each wine to one of six groups — **R1**, **R2**, **R3**, **R4**, **R5** and unclassified (from best to worst) — based on their quality performance between 1961 and 1990. Parker allocated 153 different wines to the top five categories and our data set includes observations from 132 of these wines.

The collective reputation variables, $\bar{\mathbf{R}}_{it}$, are represented by zero-one dummy variables which correspond to the government determined Bordeaux regional designations (appellations) and industry determined "quality" classifications.[3] Wine producers must include the regional designation on each wine's label and, if they are also entitled to a "quality" classification, they usually include this on the label as well. As a consequence, information on the regional designation and "quality" classification of each wine is easily available to consumers.

The dummy variables used to represent the Bordeaux regional designations correspond to the division of Bordeaux into ten regions: Fronsac and others (**FRON**), Haut-Médoc (**HMED**), Margaux (**MAR**), Graves (**GRA**), Listrac and Moulis (**LIS**), Pomerol (**POM**), Pauillac (**PAU**), St.-Emilion (**STEM**), St.-Julien (**STJU**), St.-Estèphe (**STES**), and the rest of the Médoc (**MED**). The "quality" classification dummy variables correspond to the following eleven designations: First-Growth (**FIRST**), Second-Growth (**SECOND**), Third-Growth

(THIRD), Fourth-Growth **(FOURTH)**, Fifth-Growth **(FIFTH)**, St.-Emilion *Premier Grand Cru Classé* **(SEPGCC)**, St.-Emilion *Grand Cru Classé* **(SEGCC)**, Graves *Cru Classé* **(GRACC)**, *Cru Grand Bourgeois Exceptionnel* **(CGBE)**, *Cru Grand Bourgeois* **(CGB)** and *Cru Bourgeois* **(CB)**. The base case in the estimating equations is an unclassified Médoc wine.

Non-Quality Variables

In addition to quality, reputation and collective reputation variables, the models to be estimated include variables which reflect the other characteristics that differentiate wines (the elements of $\mathbf{z}$). Since the types of grapes used to make a wine have a major impact on its taste and style, the estimating equations include the percentages grown by each producer of four of the five grape varieties that can be used to make red Bordeaux wine (Cabernet Sauvignon **(CABS)**, Cabernet Franc **(CABF)**, Malbec **(MAL)** and Petit Verdot **(PV)**) with the percentage of Merlot forming the base case. The inclusion of grape variety data in the price equations also controls for differences in land characteristics across firms since the grape varieties grown generally depend on soil type.

Two dummy variables were also included in the price equation to control for the effect of "second labels". These are the labels under which some wine producers market wine made from lower quality grapes (sometimes all their grapes in a bad vintage). The dummy variable **(PSEC)** indicates that a wine is produced by a firm that produces a second label, and the dummy variable **(FSEC)** identifies wines which are the first wines of firms that produce a second label. The existence of a second label may affect consumers' relative quality perception of the first and second wines of a producer and, thus, may alter the demand for both types of wine. Finally, the average number of cases produced by each producer **(CASES)** is included as an explanatory variable in each estimating equation to control for any impact the relative scarcity of a wine may have on its price (perhaps due to "snob effects" or the greater visibility of a more abundant wine).

Functional Form

The theories described in Section II above restrict the types of quality and reputation variables included in the price equation, but do not restrict its functional form. The hedonic price equation literature has employed a wide variety of different functional forms: linear, log-linear, semi-log, quadratic and various versions of the Box-Cox transformation (Halvorsen & Pollakowski, 1981; Mendelsohn, 1984; Palmquist, 1984; Cropper, Deck & McConnell, 1988; Stanley & Tschirhart, 1991; Parker & Zilberman, 1993). Much of this literature includes estimates of quadratic versions of the hedonic price equation. Because of the large number of explanatory variables in the reputation and collective reputation models, quadratic estimation is not feasible. However, five linear-in-their-parameters functional forms — linear, semi-log, log-linear, reciprocal (or inverse) and reciprocal square root — were tested and compared with the most appropriate of these also tested against two variants of the Box-Cox model. The results of these comparisons (see Appendix III) indicate that the reciprocal square root model provides a reasonable description of the data. As a consequence, all the estimates reported below are calculated using this functional form.

V. Empirical Results

Tables I and II present the parameter estimates associated with the extended full-information and extended reputation models, equations (4) and (5), respectively, using data for each vintage and for the entire sample (with a dummy variable for each vintage). The empirical analysis begins with an examination of these two extended models since, as noted above, the other three models are nested in one or both of them. To conserve space and make the tables easier to read, the estimated coefficients associated with the non-quality and non-reputation variables are not reported.

In the extended full-information model (Table I), the estimated coefficient associated with current quality is significant in every case and negative indicating a positive relationship between price and current quality (since price enters the dependent variable in reciprocal form). The estimates of the extended reputation model in Table II indicate that only four of the ten estimated coefficients associated with the lagged quality variables are significant, and in only four of the six cases are these two lagged variables jointly significant. However, the long term reputation variables (**R1** to **R5**) have a positive effect on price and are jointly significant in every case. As well, 29 of the 30 estimated coefficients associated with these variables are individually significant.

The significance of current quality in Table I and the long term reputation variables in Table II suggests that both the full-information and reputation models provide potentially valid descriptions of the information used by consumers. In addition, the significant coefficients associated with the current quality and reputation variables mean that the collective reputation model is rejected by both the extended full-information and extended reputation models. This implies that consumers do not rely exclusively on collective reputation signals.

Although the simple collective reputation model is rejected by both extended models, the results in both Tables I and II show that collective reputation variables are important elements in the information sets of consumers. In both tables, an F-test rejects the hypothesis that the coefficients on the regional dummy variables are jointly zero as well as the hypothesis that the coefficients on the group classification variables are zero. These results indicate that the simple full-information and reputation models are rejected by the extended full-information and extended reputation models, respectively.

The coefficient estimates and F-tests described above suggest that both extended models provide reasonable descriptions of the data. In order to further compare these two models, their specifications were tested using RESET and heteroscedasticity tests. In addition to testing for non-constant variances, a test for heteroscedasticity can be used as a general misspecification test (White, 1980). The RESET test is a general test of a model's functional form and, in addition, it performs well as a test for omitted variables (Godfrey & Orme, 1994). As indicated by the test statistics reported in Tables I and II, the heteroscedasticity test rejects the extended full-information model in two of the six cases, but only rejects the extended reputation model when the data is aggregated across time. On the other hand, the RESET test rejects the extended reputation model when the data is aggregated across time, but does not reject the extended full-information model in any case. While these test results provide a similar level of support for both models, the adjusted R^2 statistics associated with the extended reputation model are considerably higher than those for the full-information model.

Since the extended full-information and extended reputation models are not nested, they can be further compared using a non-nested test. The test statistics for the non-nested J-test proposed by Davidson and MacKinnon (1981) are presented in Table III. These test statistics indicate that the extended full-information model can clearly be rejected by the extended reputation model in every case. In contrast, the extended reputation model is only rejected by the extended full-information model for two of the six sample definitions using a 95 percent confidence interval and only for the case in which the data are aggregated across vintages using a 99 percent confidence interval. (The results of the heteroscedasticity and RESET tests associated with the extended reputation model suggest that aggregation across vintages is probably not appropriate and, thus, it is not surprising that the extended reputation model is rejected in this case.) These test results, along with the significance of the coefficient estimates and test statistics reported in Table II, suggest that, of the five models considered, the extended reputation model provides the best description of the quality and reputation indicators used by consumers in the market for Bordeaux wine.

The Extended Reputation Model — Discussion of the Estimates

The results presented above indicate that both indicators of individual firm reputation and collective reputation are used by consumers when forming their purchase decisions. However, since the dependent variable in the estimating equations is in reciprocal square root form, the comparison and interpretation of the estimated coefficients is relatively complex. To make the results more transparent, the dollar values of the marginal effects associated with each of the explanatory variables in the extended reputation model are listed in Table IV. These values can be used to compare the magnitude of short run and long run reputation on price, as well as the relative impact of individual firm and collective reputation.

The dollar values in Table IV clearly reveal that the marginal impact on price of quality lagged one period is small and insignificant. While the coefficient on the twice lagged quality variable is generally larger and significant in three cases, the impact of this variable on price is still relatively small. Averaging the estimates across years, a one point increase in quality would yield an increase in the price per bottle of nine cents in the following year and an increase of 30 cents after two years (approximately one percent of the average price). In contrast, the long term reputation variables have a relatively large and significant effect on price with the reputation premium falling as the level of reputation declines. On average, a wine with the highest long term reputation (**R1**) sells for a premium of almost $10 a bottle (or almost 40 percent of the average price) over a wine without a long term reputation (one that is not classified as **R1** through **R5**) while a wine classified as **R5** sells for a premium of $3 per bottle. These results imply that consumers are much more willing to pay a higher price for a product with a long-term reputation for quality. The small and relatively insignificant coefficients on the one and two year lagged quality terms imply that consumers do not place significant value, at the margin, on short term quality movements.

The estimated coefficients associated with the regional and classification variables in the extended reputation model reflect the impact on price of collective reputation holding each firm's individual reputation constant. As indicated by the dollar values provided in Table IV, the magnitude of the effect of the collective reputation variables on price can be quite large. For example, a First-Growth wine earns a premium of approximately $7 relative to an unclassified wine and, if it is from the Margaux region, it earns a further premium of approximately $6.50. Given that many wines have both a "quality" classification and a regional designation, the results in Table IV suggest that, at the margin, consumers value the information contained in collective reputation indicators as much as that in individual firm reputation.

The Bias if Reputation Effects are Omitted

The empirical results described above indicate the important role played by reputation in consumer decisions. As noted previously, while the importance of reputation has long been recognized in the literature, the incorporation of reputation effects in empirical studies is not widespread. However, empirical studies which ignore reputation effects may greatly overestimate the impact of current quality on consumer behaviour. The magnitude of this effect is illustrated in Table V. The estimated dollar values of the marginal effect of quality on price for a model that excludes both individual and collective reputation indicators (as in the full-information model) are given in Table V.1. The model associated with the estimates in Table V.2 excludes individual reputation effects, but includes the collective reputation indicator variables. In both cases, current quality appears to have a relatively large and significant impact on price. As a consequence, the use of either of these two models, both of which were rejected by the extended reputation model, would lead to the incorrect conclusion that the purchase decisions of consumers depend significantly on current quality.

The bias in the magnitude of the impact on price of the short term reputation effects when the collective reputation variables are not included in the reputation model are illustrated in Table V.3. These results indicate that, relative to the extended reputation model (Table IV), the basic reputation model yields more significant and larger estimates of the marginal dollar effects associated with the two lagged quality terms. This is particularly the case for the quality variable lagged once. As a consequence, the use of the reputation model that excludes the collective reputation indicator variables would lead to the incorrect conclusion that price reacts quickly to quality changes and that consumers employ short term quality movements as indicators of current quality.

VI. Summary and Conclusions

This paper examines the extent to which consumers use current quality, reputation and collective reputation indicators. Employing data from the market for Bordeaux wine, it is shown that a model that combines reputation and collective reputation variables provides a reasonable description of the information used by consumers. Furthermore, this model rejects alternative models that include current quality. These results suggest that consumers place considerable value on mechanisms that disseminate information on the past quality performance of firms.

The results also indicate that the effect on price of short term changes in quality is relatively small. This implies that consumers primarily base their purchase decisions on persistent, rather than short run, movements in quality. As well, empirical models which include only current realizations of quality or proxies for quality, and which ignore reputation variables (such as many hedonic price studies), may overstate the impact of current quality on price.

The estimates described above reveal a very important role in consumer information sets for collective reputation variables (in particular, group designations and classification schemes) even after controlling for individual firm quality and reputation. The price premia associated with the collective reputation variables is shown to be as large as that associated with individual firm reputation. This suggests that consumers form their predictions of the quality of an individual firm's output using information on the quality of the output produced by similar firms and, thus, that they place significant value, at the margin, on group quality indicators. The high value that consumers place on the government-determined regional designations and the industry-determined "quality" classifications indicates that there may be a role for both government and industry provision of information on product characteristics. The extent of the role for government will depend on the availability of private sector sources of product information and deserves further study.

Endnotes

1. Parker allocates points as follows: "The wine's general color and appearance merit up to 5 points . . . . The aroma and bouquet merit up to 15 points, depending on the intensity level and extract of the aroma and bouquet as well as the cleanliness of the wine. The flavor and finish merit up to 20 points, and again, intensity of flavor, balance, cleanliness, and depth and length on the palate are all important considerations . . . . Finally, the overall quality level or potential for further evolution and improvement - aging - merits up to 10 points" (Parker, 1991, 21).

2. The tasting procedure used by *Wine Spectator* is as follows: "Bottles are bagged and coded. Capsules are removed and corks are substituted to ensure that the wines remain anonymous. Tasters are told only the general type of wine (varietal or region) and vintage. In scoring, price is not taken into account." (*Wine Spectator*, 31 March 1993, BG4). Most of the tasting for the "Bordeaux" issue takes place in January of the year of release which is approximately three years after the vintage (or harvest) year.

3. The French government's *Appellation d'Origine Contrôlée* (AOC) system provides consumers with information on the region from which a wine's grapes originate. The most well known "quality" classification of red Bordeaux wines took place in 1855 when 61 wine makers in the Médoc and one in the Graves region were classified into five categories (from first-growth to fifth-growth) on the basis of selling price and vineyard condition. The classification was compiled by wine merchants at the request of the Bordeaux Chamber of Commerce and no provision was made for its revision. Not all current wine producers were evaluated during the 1855 classification (including those from Pomerol which today produce wines that are widely recognized as among the best in Bordeaux). In the twentieth century there have been several classifications of the lesser known wine producers. In 1932, 444 producers were classified as *Crus Bourgeois*. This classification was updated in 1966, and again in 1978, when 128 producers were classified as follows: 18 as *Crus Grands Bourgeois Exceptionneles*, 41 as *Crus Grands Bourgeois*, and 68 as *Crus Bourgeois*. This classification was undertaken by the *Syndicat des Crus Bourgeois*, and only members of the *Syndicat* were entitled to be recognized in the classification. In 1955 the "better" St. Emillion wines were classified as *Premiers Grands Crus Classés* and *Grand Crus Classés*. This classification was revised in 1959, 1969 and, most recently, in 1985 when 73 producers were included. Thirteen wine producers in Graves were singled out for *Cru Classé* status in a 1959 classification.

Table I: Extended Full Information Model — Parameter Estimates

Explanatory Variables	All Years	1987	1988	1989	1990	1991
Q	-.0034**	-.0028**	-.0046**	-.0041**	-.0027**	-.0042**
	(8.58)	(2.81)	(5.15)	(4.85)	(2.80)	(6.03)
FRON	-.0242**	-.0071	-	-.0322	-.0048	-
	(1.99)	(.21)		(1.45)	(.24)	
GRA	-.0329**	-.0612**	-.0565**	-.0376**	-.0099	-.0310**
	(3.49)	(2.76)	(2.80)	(2.21)	(.57)	(2.26)
LIS	-.0396**	-.0598**	-.0972**	-.0280**	-.0248**	-.0338**
	(5.03)	(2.70)	(4.00)	(2.10)	(2.31)	(2.16)
MAR	-.0441**	-.0547**	-.0777**	-.0490**	-.0348**	-.0142
	(5.38)	(2.31)	(4.11)	(3.30)	(2.64)	(1.20)
PAU	-.0470**	-.0685**	-.0670**	-.0522**	-.0381**	-.0213*
	(5.68)	(2.93)	(3.20)	(3.37)	(2.66)	(1.79)
POM	-.1056**	-.0805**	-.1120**	-.1128**	-.1026**	-.0959**
	(8.59)	(2.24)	(3.88)	(4.53)	(4.98)	(5.04)
STEM	-.0542**	-.0182	-.1770**	-.0568*	-.0243	-.0487**
	(3.44)	(.50)	(6.65)	(1.91)	(1.33)	(2.33)
STES	-.0369**	-.0377**	-.0652**	-.0281	-.0374**	-.0206*
	(4.66)	(2.23)	(3.02)	(1.61)	(3.02)	(1.74)
STJU	-.0419**	-.0610**	-.0603**	-.0497**	-.0294**	-.0242*
	(5.10)	(2.83)	(2.93)	(3.19)	(2.42)	(1.82)
HMED	-.0314**	-.0296	-.0547**	-.0317**	-.0349**	-.0203**
	(4.79)	(1.27)	(3.14)	(2.71)	(3.45)	(2.01)
FIRST	-.1169**	-.1184**	-.0917**	-.1140**	-.1245**	-.1166**
	(18.55)	(6.43)	(5.64)	(10.94)	(10.47)	(10.03)
SECOND	-.0591**	-.0638**	-.0525**	-.0634**	-.0575**	-.0556**
	(9.78)	(4.16)	(2.68)	(5.05)	(5.66)	(5.25)
THIRD	-.0411**	-.0626**	-.0299**	-.0372**	-.0359**	-.0538**
	(7.43)	(5.11)	(2.28)	(3.69)	(3.54)	(4.53)
FOURTH	-.0381**	-.0352	-.0406**	-.0360**	-.0426**	-.0331**
	(5.64)	(1.65)	(2.15)	(3.01)	(4.41)	(2.58)
FIFTH	-.0259**	-.0400*	-.0239	-.0174	-.0293**	-.0264**
	(4.29)	(1.92)	(1.53)	(1.51)	(2.50)	(2.79)
CGBE	-.0098	-.0148	.0050	-.0218	-.0104	.0035
	(1.50)	(.57)	(.21)	(1.45)	(1.13)	(.32)

CGB	.0003 (.05)	-.0138 (.86)	-.0190 (1.44)	.0029 (.22)	.0110 (1.23)	.0086 (.81)
CB	-.0013 (.22)	-	.0159 (1.24)	.0019 (.15)	-.0057 (.59)	.0052 (.50)
SEPGCC	-.0439** (3.36)	-.1151** (5.60)	.0500** (2.25)	-.0357 (1.54)	-.0638** (5.29)	.0165 (1.01)
SEGCC	-.0093 (.76)	-.0948** (6.09)	.0884** (8.59)	.0002 (.01)	-.0248** (2.11)	-.0068 (.41)
GRACC	-.0431** (4.55)	-.0308** (2.19)	-.0447* (1.96)	-.0381** (2.16)	-.0572** (3.04)	-.0255 (1.27)
#OBS	559	54	94	151	151	109
$\bar{R}^2$	.742	.635	.595	.674	.687	.716
RESET test (d.o.f.)	1.96 (1,524)	.34 (1,25)	.98 (1,64)	.59 (1,120)	.18 (1,120)	.28 (1,79)
Breusch-Pagan Heterosce-dasticity test (d.o.f.)	96.45†† (33)	28.11 (28)	21.10 (28)	36.76 (29)	48.85†† (29)	36.08 (28)
F-test that coefficients on region variables equal zero	14.05‡ (10,525)	12.22‡ (10,25)	8.42‡ (9,65)	3.99‡ (10,121)	7.66‡ (10,121)	3.66‡ (9,80)
F-test that coefficients on classification variables equal zero	46.66‡ (11,525)	18.46‡ (10,25)	34.30‡ (11,65)	18.46‡ (11,121)	13.61‡ (11,121)	16.58‡ (11,80)

Notes: The number in brackets under each estimated coefficient is the absolute value of the t-statistic calculated using White's (1980) heteroscedasticity consistent covariance matrix. The number in brackets below each test statistic is the degrees of freedom for that test.

** - Significant at 95 percent.
 * - Significant at 90 percent.

† - RESET test rejects at 5 percent.
†† - Breusch-Pagan Heteroscedasticity test rejects homoscedasticity at 5 percent.

‡ - Rejects zero restrictions at 5 percent.

Table II: Extended Reputation Model — Parameter Estimates

Explanatory Variables	All Years	1987	1988	1989	1990	1991
Q_{-1}/V_{-1}	-.0297	.0641	-.0108	-.0578	-.0571	-.1219**
	(1.45)	(1.05)	(.22)	(1.59)	(1.22)	(2.28)
Q_{-2}/V_{-2}	-.0625**	-.3913**	-.0804	-.0827**	-.0131	-.0567
	(3.07)	(6.49)	(1.54)	(2.36)	(.32)	(1.04)
R1	-.0953**	-.0901**	-.0922**	-.0978**	-.0971**	-.0889**
	(17.76)	(9.49)	(6.78)	(8.48)	(11.67)	(10.64)
R2	-.0610**	-.0633**	-.0509**	-.0649**	-.0657**	-.0573**
	(15.11)	(8.73)	(4.41)	(8.15)	(11.72)	(7.94)
R3	-.0416**	-.0410**	-.0358**	-.0459**	-.0393**	-.0352**
	(12.20)	(3.52)	(3.61)	(7.21)	(8.03)	(5.08)
R4	-.0341**	-.0411**	-.0311**	-.0317**	-.0330**	-.0377**
	(7.55)	(4.64)	(2.32)	(3.34)	(4.29)	(5.05)
R5	-.0208**	-.0494**	-.0016	-.0261**	-.0168**	-.0233**
	(7.88)	(5.64)	(.21)	(4.54)	(4.69)	(5.64)
FRON	-.0352**	-.0191	-	-.0427**	-.0237	-
	(3.27)	(1.11)		(2.65)	(1.52)	
GRA	-.0440**	-.0746**	-.0968**	-.0541**	-.0216	-.0130
	(4.66)	(6.08)	(3.43)	(4.31)	(1.51)	(1.51)
LIS	-.0482**	-.0580**	-.1145**	-.0523**	-.0285**	-.0389**
	(5.91)	(3.68)	(3.78)	(5.09)	(2.75)	(4.52)
MAR	-.0546**	-.0397**	-.0976**	-.0661**	-.0491**	-.0161*
	(6.49)	(3.30)	(3.75)	(6.15)	(4.38)	(1.85)
PAU	-.0492**	-.0681**	-.0901**	-.0554**	-.0416**	-.0146*
	(6.07)	(5.82)	(3.69)	(5.86)	(3.67)	(1.79)
POM	-.1021**	-.0698**	-.1277**	-.1149**	-.0985**	-.0644**
	(9.54)	(3.44)	(4.09)	(7.30)	(6.46)	(4.33)
STEM	-.0603**	-.0209	-.1203**	-.0773**	-.0559**	-.0230
	(4.71)	(.93)	(3.82)	(5.04)	(2.41)	(1.48)
STES	-.0422**	-.0383**	-.0816**	-.0395**	-.0448**	-.0156**
	(5.36)	(4.57)	(3.00)	(3.64)	(4.11)	(2.20)
STJU	-.0455**	-.0669**	-.0745**	-.0582**	-.0339**	-.0151*
	(5.45)	(5.52)	(2.99)	(5.49)	(2.97)	(1.69)
HMED	-.0376**	-.0718**	-.0606**	-.0429**	-.0346**	-.0244**
	(5.25)	(7.14)	(2.55)	(4.75)	(3.38)	(3.57)
FIRST	-.0601**	-.0781**	-.0416**	-.0528**	-.0619**	-.0642**
	(9.54)	(8.67)	(2.47)	(4.52)	(6.26)	(5.59)
SECOND	-.0221**	-.0212**	-.0003	-.0306**	-.0176**	-.0272**
	(4.07)	(2.71)	(.02)	(2.88)	(2.19)	(3.49)
THIRD	-.0258**	-.0371**	-.0316**	-.0200**	-.0204**	-.0384**
	(5.59)	(4.33)	(2.48)	(2.15)	(3.82)	(4.38)
FOURTH	-.0244**	-.0496**	-.0298*	-.0194*	-.0227**	-.0226**
	(4.46)	(6.10)	(1.92)	(1.91)	(2.72)	(2.24)

FIFTH	-.0270** (6.02)	-.0352** (4.72)	-.0299** (2.21)	-.0213** (2.46)	-.0269** (4.51)	-.0258** (3.55)
CGBE	-.0128** (2.25)	-.0248 (1.66)	.0090 (.37)	-.0202* (1.81)	-.0166** (2.29)	-.0004 (.06)
CGB	-.0121** (2.28)	-.0197** (3.17)	-.0413** (2.84)	-.0101 (1.04)	-.0079 (1.23)	.0004 (.04)
CB	-.0134** (2.54)	-	.0061 (.36)	-.0064 (.77)	-.0177** (2.47)	-.0120* (1.86)
SEPGCC	-.0361** (3.69)	-.1043** (10.67)	-.0236 (1.26)	-.0224** (2.11)	-.0359* (1.85)	.0230** (2.02)
SEGCC	-.0195** (2.15)	-.1054** (7.31)	-.0014 (.13)	-.0092 (.84)	-.0144 (.76)	-.0209** (2.12)
GRACC	-.0325** (4.67)	-.0271** (2.94)	-.0142 (.75)	-.0251** (2.00)	-.0445** (3.65)	-.0286** (2.33)
#OBS	559	54	94	151	151	109
$\bar{R}^2$	.860	.916	.728	.839	.877	.855
RESET test (d.o.f.)	5.55† (1,518)	.18 (1,18)	.11 (1,58)	1.56 (1,114)	2.04 (1,114)	1.58 (1,73)
Breusch-Pagan Heteroscedasticity test (d.o.f.)	71.91†† (39)	44.40 (34)	35.33 (34)	37.68 (35)	39.20 (35)	37.64 (34)
F-test that coefficients on region variables equal zero	19.44‡ (10,519)	29.14‡ (10,19)	4.21‡ (9,59)	9.18‡ (10,115)	18.29‡ (10,115)	6.97‡ (9,74)
F-test that coefficients on classification variables equal zero	11.48‡ (11,519)	37.30‡ (10,19)	3.36‡ (11,59)	2.56‡ (11,115)	6.08‡ (11,115)	5.75‡ (11,74)
F-test that coefficients on Q_{-1} and Q_{-2} equal zero	7.10‡ (2,519)	21.40‡ (2,19)	1.80 (2,59)	4.50‡ (2,115)	.97 (2,115)	4.23‡ (2,74)
F-test that coefficients on R1 to R5 equal zero	73.70‡ (5,519)	26.30‡ (5,19)	12.29‡ (5,59)	18.46‡ (5,115)	37.23‡ (5,115)	31.55‡ (5,74)

See notes to Table I.

Table III: Extended Full-Information and Extended Reputation Models — Non-Nested Tests

Test of the Extended Full-Information Model

Alternative Model:	Sample: All Years	1987	1988	1989	1990	1991
Extended Reputation	22.21†	11.08†	6.77†	12.08†	14.45†	9.58†

Test of the Extended Reputation Model

Alternative Model:	Sample: All Years	1987	1988	1989	1990	1991
Extended Full-Information	4.72†	1.35	1.78	2.05†	1.78	1.24

Notes: The test statistics are asymptotic t-statistics.
† - the alternative model rejects the model being tested at 95 percent.

Table IV: Extended Reputation Model — Real Dollar Marginal Effects

Explanatory Variables	All Years	1987	1988	1989	1990	1991
Q_{-1}	.08	-.12	.04	.22	.17	.15*
Q_{-2}	.18*	.75*	.22	.40*	.04	.07
R1	9.48*	8.42*	10.42*	12.13*	10.65*	5.69*
R2	7.12*	6.68*	7.05*	9.46*	8.36*	4.18*
R3	5.37*	4.83*	5.39*	7.42*	5.75*	2.84*
R4	4.58*	4.85*	4.81*	5.56*	5.01*	3.01*
R5	3.02*	5.58*	.30	4.74*	2.81*	1.99*
FRON	4.70*	2.54	-	7.02*	3.79	-
GRA	5.60*	7.47*	10.72*	8.35*	3.51	1.17
LIS	6.01*	6.28*	11.75*	8.15*	4.44*	3.09*
MAR	6.58*	4.71*	10.77*	9.57*	6.81*	1.43
PAU	6.09*	7.02*	10.28*	8.49*	6.01*	1.30
POM	9.87*	7.14*	12.41*	13.22*	10.74*	4.56*
STEM	7.06*	2.75	12.05*	10.57*	7.48*	1.97
STES	5.42*	4.58*	9.69*	6.61*	6.37*	1.39*
STJU	5.75*	6.94*	9.15*	8.78*	5.12*	1.35
HMED	4.95*	7.28*	7.98*	7.05*	5.20*	2.07*
FIRST	7.05*	7.69*	6.07*	8.21*	8.03*	4.55*
SECOND	3.18*	2.79*	.05	5.41*	2.93*	2.28*
THIRD	3.64*	4.47*	4.87*	3.77*	3.34*	3.05*
FOURTH	3.46*	5.60*	4.64	3.68	3.67*	1.94*
FIFTH	3.77*	4.28*	4.66*	3.99*	4.23*	2.18*
CGBE	1.94*	3.20	-1.81	3.81	2.78*	.04
CGB	1.85*	2.61*	6.03*	2.03	1.39	-.04
CB	2.03*	-	-1.19	1.32	2.95*	1.09
SEPGCC	4.79*	9.17*	3.82	4.16*	5.35	-2.53*
SEGCC	2.85*	9.23*	.27	1.86	2.45	1.81*
GRACC	4.41*	3.45*	2.44	4.60*	6.33*	2.38*
Average Price:	25.10	20.22	25.37	31.50	27.53	15.08

Note: * - the coefficient associated with the explanatory variable is significant at 95 percent.

Table V: Real Dollar Marginal Quality Effects in the Models that Omit the Reputation Variables

Table V.1: Full-Information Model (Excludes Individual and Collective Reputation Variables)

Quality Measure:	All Years	1987	1988	1989	1990	1991
	Sample					
Q	1.82*	.73*	1.76*	2.95*	2.13*	.85*

Table V.2: Extended Full-Information Model (Excludes Individual Reputation Variables)

	All Years	1987	1988	1989	1990	1991
	Sample					
Q	.85*	.52*	1.17*	1.43*	.79*	.49*

Table V.3: Reputation Model (Excludes Collective Reputation Variables)

	All Years	1987	1988	1989	1990	1991
	Sample					
Q_{-1}	.24*	.39	-.10	.46*	.61*	.17*
Q_{-2}	.24*	.78*	.20	.23	.22	.17*

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*Coefficient associated with the quality variable is significant at 95 percent.

Appendix I: Variable Definitions and Data Sources

CABF - a wine producer's average percentage of the Cabernet Franc grape variety. Source: Parker (1991) except for a small number of wines which were not included in Parker for which data from Molyneux-Berry (1990) was used. Second labels were assumed to have the same grape composition as first labels.

CABS - average percentage of grapes in the wine which are of the Cabernet Sauvignon variety. Source is the same as for **CABF**.

CASES - average number of cases produced by a wine producer (in thousands). Source: Parker (1991).

CB - a dummy variable which equals one if the wine was classified as a *Cru Bourgeois* in the 1978 Médoc classification and zero otherwise. Source: Parker (1991, 930-1). The variable **CB** was excluded from the 1987 estimates because no wines included in the data set fell into this category during that year.

CGB - a dummy variable which equals one if the wine was classified as a *Cru Grand Bourgeois* in the 1978 Médoc classification and zero otherwise. Source: Parker (1991, 929-30).

CGBE - a dummy variable which equals one if the wine was classified as a *Cru Grand Bourgeois Exceptionnel* in the 1978 Médoc classification and zero otherwise. Source: Parker (1991, 929).

FIFTH - a dummy variable which equals one if the wine was classified as a Fifth-Growth in the classification of 1855 and zero otherwise. Source: Parker (1991, 925).

FIRST - a dummy variable which equals one if the wine was classified as a First-Growth in the classification of 1855 and zero otherwise. Source: Parker (1991, 924).

FOURTH - a dummy variable which equals one if the wine was classified as a Fourth-Growth in the classification of 1855 and zero otherwise. Source: Parker (1991, 925).

FRON - a dummy variable which equals one if the wine has a Fronsac or Bordeaux appellation and zero otherwise. Source is the same as for **Q**. The **FRON** variable was not included in the estimating equations for 1988 and 1991 because no wines included in the data set fell into this category for those years.

FSEC - a dummy variable which equals one if the wine is a first wine that has a second label and zero otherwise. Source: Parker (1991) except for a small number of wines which were not included in Parker for which data from Molyneux-Berry (1990) was used.

GRA - a dummy variable which equals one if the wine has a Graves appellation and zero otherwise. Source is the same as for **Q**.

GRACC - a dummy variable which equals one if the wine was classified (*Cru Classé*) in the 1959 Graves classification and zero otherwise. Chateau Haut-Brion was included in the First Growth category and not the Graves *Cru Classé* category because it is the only wine which is recognized in two categories. Source: Parker (1991, 926).

HMED - a dummy variable which equals one if the wine has an Haut-Médoc appellation and zero otherwise. Source is the same as for **Q**.

LIS - a dummy variable which equals one if the wine has a Listrac or Moulis appellation and zero otherwise. Source is the same as for **Q**.

MAL - average percentage of grapes in the wine which are of the Malbec variety. Source is the same as for **CABF**.

MAR - a dummy variable which equals one if the wine has a Margaux designation and zero otherwise. Source is the same as for **Q**.

P - the price per bottle of wine in 1985 US dollars. The source of the nominal prices is the same as for **Q**. The deflator is the quarterly average of the US CPI in the first quarter of the year in which the wine is released. This price index is reported in the International Monetary Fund's International Financial Statistics except for the first quarter 1994 value which was calculated using the change in the CPI from the first quarter 1993 to February 1994 with the later value being from The Economist, 9 April 1994, 114.

PAU - a dummy variable which equals one if the wine has a Pauillac designation and zero otherwise. Source is the same as for **Q**.

POM - a dummy variable which equals one if the wine has a Pomerol designation and zero otherwise. Source is the same as for Q.

PSEC - a dummy variable which equals one if the wine is a second wine or is the first wine of a producer that also produces a second wine and zero otherwise. Source is the same as for FSEC.

PV - average percentage of grapes in the wine which are of the Petit Verdot variety. Source is the same as for CABF.

Q - quality measure (100 point maximum, 50 point minimum). Source: 1987: Tasting the 87 Bordeaux. Wine Spectator, 15(3), 46-9. 1988: 88 Bordeaux Tasting Notes. Wine Spectator, 16(2). 1989: Rating 1989 Bordeaux Reds. Wine Spectator, 16(21), 26-32. 1990: Rating Bordeaux's Generous '90s. Wine Spectator, 17(22), 30-39. 1991: 1991 Bordeaux in Review. Wine Spectator, 18(21), 83-89.

Q_{-1} - lagged quality. Source is the same as for Q except for the 1986 observations which come from Shanken (1993).

Q_{-2} - twice lagged quality. Source is the same as for Q except for the 1985 and 1986 observations which come from Shanken (1993).

R1 - a dummy variable which equals one if a wine producer is included in Parker's list of "First-Growths" and zero otherwise. Source: Parker (1991, 932).

R2 - a dummy variable which equals one if a wine producer is included in Parker's list of "Second-Growths" and zero otherwise. Source: Parker (1991, 933).

R3 - a dummy variable which equals one if a wine producer is included in Parker's list of "Third-Growths" and zero otherwise. Source: Parker (1991, 933).

R4 - a dummy variable which equals one if a wine producer is included in Parker's list of "Fourth-Growths" and zero otherwise. Source: Parker (1991, 933).

R5 - a dummy variable which equals one if a wine producer is included in Parker's list of "Fifth-Growths" and zero otherwise. Source: Parker (1991, 933-4).

SECOND - a dummy variable which equals one if the wine was classified as a Second-Growth in the official classification of 1855 and zero otherwise. Source: Parker (1991, 924).

SEGCC - a dummy variable which equals one if the wine was classified as a *Grand Cru Classé* in the 1985 St. Emilion classification and zero otherwise. Source: Parker (1991, 928-9).

SEPGCC - a dummy variable which equals one if the wine was classified as a *Premier Grand Cru Classé* in the 1985 St. Emilion classification and zero otherwise. Source: Parker (1991, 928).

STEM - a dummy variable which equals one if the wine has a St. Emilion designation and zero otherwise. Source is the same as for Q.

STES - a dummy variable which equals one if the wine has a St. Estèphe designation and zero otherwise. Source is the same as for Q.

STJU - a dummy variable which equals one if the wine has a St. Julien designation and zero otherwise. Source is the same as for Q.

THIRD - a dummy variable which equals one if the wine was classified as a Third-Growth in the official classification of 1855 and zero otherwise. Source: Parker (1991, 924-5).

V_{-1} - the average quality of the previous vintage in Bordeaux. Source: Rating Bordeaux Vintages 1961-1991. Wine Spectator, 18(21), 35.

V_{-2} - the average quality of the vintage two years before. Source is the same as for V_{-1}.

Appendix II: Data Summary Statistics

	All Years	1987	1988	1989	1990	1991
# Obs	559	54	94	151	151	109
Q	87.2	82.5	89.0	90.0	89.7	80.5
Q_{-1}	87.3	90.4	79.8	86.9	89.8	89.2
Q_{-2}	86.0	90.1	88.0	79.2	86.9	90.2
R1	65 (12)	10 (19)	11 (12)	15 (10)	17 (11)	12 (11)
R2	60 (11)	11 (20)	11 (12)	16 (11)	15 (10)	7 (6)
R3	87 (16)	11 (20)	15 (16)	23 (15)	21 (14)	17 (16)
R4	42 (8)	7 (13)	6 (6)	9 (6)	11 (7)	9 (8)
R5	132 (23)	12 (22)	26 (28)	37 (25)	34 (23)	23 (21)
Not R1-R5*	173 (31)	3 (6)	25 (27)	51 (34)	53 (35)	41 (38)
FIRST	23 (4)	3 (6)	5 (5)	5 (3)	5 (3)	5 (5)
SECOND	45 (8)	7 (13)	6 (6)	10 (7)	12 (8)	10 (9)
THIRD	37 (7)	3 (6)	8 (9)	11 (7)	8 (5)	7 (6)
FOURTH	30 (5)	5 (9)	5 (5)	7 (5)	6 (4)	7 (6)
FIFTH	49 (9)	4 (7)	9 (10)	14 (9)	10 (7)	12 (11)
CGBE	39 (7)	4 (7)	5 (5)	10 (7)	10 (7)	10 (9)
CGB	46 (8)	3 (6)	8 (9)	13 (9)	13 (9)	9 (8)
CB	22 (4)	0 (0)	4 (4)	6 (4)	7 (5)	5 (5)
SEPGCC	29 (5)	4 (7)	4 (4)	10 (7)	10 (7)	1 (1)
SEGCC	43 (8)	3 (6)	9 (10)	11 (7)	12 (8)	8 (7)
GRACC	42 (8)	6 (11)	8 (9)	11 (7)	11 (7)	6 (6)
Unclassified*	154 (28)	12 (22)	23 (24)	43 (28)	47 (31)	29 (27)
FRON	11 (2)	1 (2)	0 (0)	4 (3)	6 (4)	0 (0)
GRA	65 (12)	7 (13)	12 (13)	19 (13)	16 (11)	11 (10)
LIS	25 (4)	2 (4)	5 (5)	6 (4)	7 (5)	5 (5)
MAR	74 (13)	7 (13)	14 (15)	19 (13)	19 (13)	15 (14)
PAU	74 (13)	7 (13)	14 (15)	19 (13)	16 (11)	18 (17)
POM	52 (9)	4 (7)	8 (9)	14 (9)	19 (13)	7 (6)
STEM	82 (15)	8 (15)	14 (15)	24 (16)	25 (17)	11 (10)
STES	44 (8)	5 (9)	5 (5)	11 (7)	11 (7)	12 (11)
STJU	58 (10)	9 (17)	10 (11)	12 (8)	14 (9)	13 (12)
HMED	58 (10)	3 (6)	10 (11)	18 (12)	14 (9)	13 (12)
MEDOC*	16 (3)	1 (2)	2 (2)	5 (3)	4 (3)	4 (4)
CABF	11.8	12.8	12.6	12.2	12.7	8.8
CABS	46.9	50.4	46.7	45.7	42.7	53.1
MAL	.3	.4	.5	.3	.3	.2
PV	1.6	1.8	1.9	1.5	1.4	1.7
Merlot*	39.4	34.7	38.4	40.3	43.0	36.2
PSEC	369 (66)	43 (80)	65 (69)	93 (62)	96 (64)	72 (66)
FSEC	347 (62)	41 (76)	61 (65)	87 (58)	91 (60)	67 (61)
CASES	16.2	17.7	16.9	15.7	15.1	16.9
V_{-1}	91.3	95	73	92	98	95
V_{-2}	88.8	95	95	73	92	98

Note: Values are averages for the period for non-dummy variables and the number of observations for which a dummy variable equals one for dummy variables. The numbers in brackets give the percentage of the sample for which the dummy variable equals one.

* - These variables comprise the base case in the estimating equation.

Appendix III: Choice of Functional Form

The appropriate functional form was chosen by estimating a price equation for each of the five competing functional forms and then calculating and comparing the corresponding Breusch-Pagan heteroscedasticity and RESET test statistics. In each case, the functional form is estimated using as regressors all the explanatory variables included in the three models described in the text (38 variables including a constant). As a result, this comparison should not suffer from excluded variable bias. Table AI reports these test statistics for estimates which combine data from all five vintages as well as for each vintage separately. The hypothesis of homoscedasticity is rejected for all five functional forms when the five years of data are combined (and only the constant is allowed to differ across years), an indication that intertemporal aggregation may be inappropriate. In contrast, when data from each vintage is used separately, the hypothesis of homoscedasticity is rejected in only four of 25 cases (three of which correspond to the reciprocal model).

The RESET test rejects four of the five functional forms a minimum of three times each. The linear model is rejected in every case and the reciprocal model is rejected four times. The reciprocal square root model, in contrast, is not rejected by the RESET test for any of the six different sets of data.

Given the results of both the heteroscedasticity and RESET tests, the reciprocal square root functional form seems more appropriate than the other four specifications. To investigate this choice further, Table AII presents the results of tests which directly compare the reciprocal square root model to several alternative specifications. The first test compares this model to the other four functional forms that are linear in their parameters using the P_E form of the non-nested test derived by MacKinnon, White and Davidson (1983). Of the 20 non-nested test statistics reported in this Table, in only two cases is the reciprocal square root model rejected by one of the other functional forms using a 95 percent confidence interval (although in neither case would it be rejected at 99 percent). (Test statistics are not provided for the case in which data from all five vintages is combined due to the heteroscedasticity test results reported in Table AI.)

The likelihood ratio tests in the lower half of Table AII compare the reciprocal square root functional form to two different versions of the Box-Cox transformation. The first of these is the standard Box-Cox transformation in which only the dependent variable is transformed. The second involves the usual transformation of the dependent variable as well as the transformation of the explanatory variables (only those which are always positive) by a potentially different transformation parameter than that used to transform the dependent variable. The reciprocal square root model is nested within both these transformations since it restricts the transformation parameters associated with the dependent and explanatory variables to -.5 and 1 respectively. For only two of the 10 tests undertaken are the restrictions implied by the reciprocal square root model rejected by the more general Box-Cox transformation using a 95 percent confidence interval and in both these cases the restrictions would not be rejected using a 99 percent confidence interval. (When the explanatory variables were transformed, the likelihood function was maximized using a grid search (intervals equal to .1) with the explanatory variable transformation parameter allowed to vary from 1.5 to -1.0. The transformation of the explanatory variables did not have much impact on the test results relative to the transformation of the dependent variable. Linneman (1980) also finds that his results are sensitive to the dependent variable transformation, but not to the transformation of the explanatory variables.)

The test results presented in Tables AI and AII suggest that the reciprocal square root model provides a reasonable description of the data. It passes several basic tests and is only rejected a small percentage of the time by other linear-in-parameters functional forms or Box-Cox alternatives when a 95 percent confidence interval is used and not at all if a 99 percent confidence interval is employed.

Table AI: Functional Form Tests

Model	Heteroscedasticity Test					
	All Years	1987	1988	1989	1990	1991
Linear	74.8†	36.1	38.4	42.1	33.3	55.8†
Semi-Log	86.8†	42.6	32.0	44.4	40.2	46.5
Log-Linear	82.9†	42.1	33.1	45.0	37.0	42.7
Reciprocal	93.3†	48.6†	49.3†	52.9†	47.0	38.8
Reciprocal Square Root	75.6†	46.2	37.7	43.5	34.0	41.7
Degrees of Freedom for Test (distributed as a χ^2 statistic)	35	34	34	35	35	34

Model	RESET Test					
	All Years	1987	1988	1989	1990	1991
Linear	335.3††	6.9††	17.1††	66.7††	88.8††	10.3††
Semi-Log	81.0††	1.8	.0002	9.3††	39.9††	2.5
Log-Linear	82.2††	1.6	.02	8.6††	29.6††	2.0
Reciprocal	8.5††	.4	14.0††	16.0††	6.7††	.03
Reciprocal Square Root	3.4	.9	3.4	1.0	1.6	.8
Degrees of Freedom for Test (distributed as a F-statistic)	1,522	1,18	1,58	1,114	1,114	1,73

† - Rejects homoscedasticity at 95 percent.

†† - Rejected by RESET test at 95 percent.

Table AII: Reciprocal Square Root Model Compared to Other Models

Alternative Models:	P_E Non-Nested Test 1987	1988	1989	1990	1991
Linear	.14	1.44	.13	2.45†	.45
Semi-Log	.54	1.62	.28	2.05†	.19
Log-Linear	.54	1.28	.25	1.49	.55
Reciprocal	.96	1.84	1.01	1.26	.87

Alternative Models:	Likelihood Ratio Test 1987	1988	1989	1990	1991
Box-Cox Dependent Variable Transformed Only (1 degree of freedom)	1.98	6.40†	2.66	1.92	.92
Box-Cox Dependent Variable and Positive Explanatory Variables Transformed by Different Parameters (2 degrees of freedom)	2.06	7.24†	4.38	2.70	.30

† - Reciprocal Square Root Model is rejected by the alternative model at 95 percent. The critical value for the P_E test is 1.96 while the critical values for the likelihood ratio tests for the first and second Box-Cox alternatives are 3.84 and 5.99, respectively.

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