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Red Wines of Médoc: What is Wine Tasting Worth?*

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Abstract

Winemaking is a highly complex technology. It needs inputs over which there is no control (good weather conditions), initial endowments which can hardly be modified (soil, exposure of the slopes), inputs which take 20 to 30 years before producing good quality outputs (vines), manual operations (picking), mechanical operations (crushing, racking) and chemical processes (during fermentation). In the paper, we disentangle the production technology, and try to quantify the impact on prices (qualities) of each of the many inputs (including weather conditions) and steps used in producing wine in Médoc. We show that technology and weather conditions are able to explain two thirds of the variance of prices; when reputation effects (based on the wine classification made in 1855) are included, this proportion rises to almost 85%. This suggests either that "classified" producers are able to charge higher prices, or that the classification is a measure of quality reflected by prices. We also show that two of the more recent attempts at classifying wines are not as good at explaining prices than the official (and old) 1855 classification. (JEL Classification: L66, Z19, C5, D4)

Keywords: decomposition of winemaking, 1855 Bordeaux classification, comparison with Parker and Dussert-Gerbert.

I. Introduction

Winemaking is probably one of the most complex technologies that produces consumption goods. It needs inputs over which there is little or no control (good weather conditions), initial endowments which can hardly be modified (soil, exposure of the slopes), inputs which take 20 to 30 years before producing good quality outputs (vines), manual operations (picking), mechanical operations (crushing, racking), delicate chemical processes (during fermentation) and specific

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storage conditions once the wine is bottled. There is usually little that can be done to correct an error in one of the various and delicate steps that extend over several years for every vintage. Wine is also the subject of many legends and production "secrets;" wine tasting adds to this aura of mystery with its esoteric vocabulary describing, under bizarre names, perfumes and appearance of wines.

The literature on wine tasting is large, but there is little on the economics of wine producing; in his 1989 paper, Orley Ashenfelter (1989) discusses wine auctions; the various issues of *Liquid Assets*, edited by Ashenfelter, discuss wines as an asset, while wine ratings is the main concern of most books like Alexis Lichine (1963), Robert Parker (1985, 1990), and many others. Nerlove (1992) estimates a demand function for Sweden and shows, among other things, that tasters' evaluations play an insignificant role in consumer choices, although quality, as defined by tasters, is associated with higher prices.

We are interested in disentangling the production technology, and in trying to quantify the impact of each of the many inputs (including weather conditions) and steps used in producing wine in one of the most renowned winemaking regions of France, Médoc and its well-known châteaux, like Mouton-Rothschild, Latour, Lafite-Rothschild and Margaux.

The database we use was painstakingly constructed by conducting interviews in 102 châteaux on characteristics of the vineyards, technologies used and prices of the vintages still sold by the château in 1990. We also collected data on weather conditions that prevailed during the years 1980 to 1989. We assumed that this would allow us to quantify the wine processing technology and to separate its effects from legend on the one hand, and from reputation effects on the other.

The paper is organized as follows. In Section II, we describe our data, based on interviews conducted in 102 châteaux. Sections III and IV are devoted to the making of Bordeaux wines; in Section III, we discuss both the technology and the results of a regression of wine prices on variables describing the technologies used. Technology and weather conditions only explain some 67% of the variance of prices; wines from Médoc (and some others, including Sauternes-Barsac) were graded in 1855, and this grading appears on the labels (First- to Fifth-Growth, Crus Bourgeois[1]); obviously this is taken as a quality signal and may partly generate the price structure; in Section IV, we include these classification variables into the regression, and derive coefficients which summarize the effects of unobserved variables; they may also be rents captured by producers, and result from the official 1855 classification. Many wine critics have criticized this classification as not reflecting the qualities of currently produced wines, and propose other classifications.[2] In Section VI,

[1] Crus Bourgeois were classified much later (1978). Graves were classified in 1959, St. Emilion in 1955 and 1985.

[2] Of course, only the 1855 classification appears on the labels.

we examine whether two such updated classifications, assumed to account for recent information on quality, have more power in explaining prices than the 1855 grading; the results show that "1855" still does better for most wines. Section VII concludes the paper.

Throughout the paper, the dependent variable of our regressions is the price of wine, assumed to reflect quality. The wines included in our sample are among the best known, longest existing, most often tasted, described and ranked; prices which do not represent quality (including scarcity) are unlikely to be sustainable for very long: as Lincoln seems to have said not all the people can be fooled all the time. Even for the wines of lesser quality included in Nerlove's (1992) sample (the majority of which clusters between $7 and $11), there is an association between quality, as defined by tasters' evaluation, and prices.

II. Data

Data on 102 châteaux of the Médoc region were collected during the winter and spring 1990–1991; each of the châteaux was visited individually, and a questionnaire was handed out with some thirty questions on types of soil, grape varieties, exposure of the vineyards, age of vines, picking techniques, vinification and élevage. The questions were "closed" to make quantification easy; some of the answers are quantitative (such as the proportions of grape varieties), but most of them are qualitative (and are represented by dummy variables), since they describe production techniques.

Each château was also asked to provide prices at which it was selling its different vintages, if possible from the last ten years (1980–1989). Some châteaux could give such prices for some vintages only, since they did not have all the wines from the ten last vintages in their cellars; in total, we collected 808 prices for the 102 châteaux. All prices are thus for wines of different vintages sold in late 1990 early 1991.

The Institut de Météorologie Nationale Française in Mérignac and Cissac provided data on weather (temperature, rainfall, hail, frost). We could only get hold of average data over the whole region and no data on the microclimate prevailing for each château. This is not too restrictive, since the region is barely 30 miles long and 5 miles wide.

The results discussed in the rest of the paper are based on equations in which the logarithm of prices (assumed to represent quality) is regressed on weather conditions as well as physical and technical characteristics of the individual châteaux. The equations are fitted by ordinary least squares; it proved difficult to use more sophisticated techniques (in order to take into account possible heteroskedasticities), since the number of chronological observations per château was not always the same: in some cases, ten price observations (i.e., prices over ten years) were available; in other cases, there were only five such observations. As a consequence,

the standard deviations of the coefficients may be underestimated, and allowance should be made for this bias when interpreting the results.

III. The Making of Bordeaux Wines

In this section, we discuss the various steps that are usually thought to contribute to the quality of a wine. These can be classified as follows: weather conditions, soil, grape varieties, exposure of the slopes where vines are grown, age of vines, vinification and élevage, appellations (to take account of regional elements not captured otherwise), and aging of the wine.

The regression results that are described are based on 808 observations (102 châteaux), and include 54 variables (plus the intercept). The overall fit is good, given the nature of the data: the variables account for over 67% of the variance of (the log of) prices.

Each characteristic will be considered in turn, and the results of the regression including these characteristics will be described. The discussion is somewhat technical, but since we deal with rather elaborate production processes (especially in the vinification and élevage steps), there is hardly any other way to go. The regression results referred to in the text appear in Table 1, under the heading "restricted regression;" this regression does not include the influence on prices of the 1855 classification, which distinguishes so-called Growth-wines from others. The results of this second equation, the "full regression" will be discussed in Section IV.

A. Weather

Red wine grapes are dormant between November and March and weather conditions are important between April and September only.[3] In the beginning of April, vines come into bud, and frost may still be a problem. This was observed only once, during seven days in 1984. The other problem in April is hail, which can cause widespread damage to the coming vintage and even to subsequent vintages.

Rain is useful between April and June, but the main determinants seem to be heat, sunshine and dry weather between mid-July and mid-September; harvesting usually starts after September 15; late harvesting (beginning of October) is the sign of previous poor weather conditions and leads to poor vintages.

Estimation results show that hail (the influence of which is captured by the variable *Hail*, measuring the number of days of hail in April) has a strongly negative and significant influence on prices. The results are less clear for heat (variables *Temp3* to *Temp6*, measuring the difference between maximum temperatures and

[3] Winters are relatively mild in Bordeaux and vines can stand temperatures as low as −16 °C.

Table 1
Regression Results

	Restr. Regression		*Full regression*	
Variables	*Coeff.*	*St. err.*	*Coeff.*	*St. err.*
Weather				
Hail	−1.24610*	.41334	−1.30730*	.29261
Temperature				
Temp3 (June)	.50887*	.10667	.52376*	.07550
Temp4 (July)	−.48679*	.12067	−.50579*	.08542
Temp5 (August)	−.52119*	.12504	−.53786*	.08851
Temp6 (September)	−.21122*	.08776	−.22737*	.06213
Rainfall				
Rain3 (June)	.00067	.00083	.00075	.00059
Rain4 (July)	.00877*	.00269	.00907*	.00191
Rain5 (August)	−.00350*	.00193	−.00357*	.00137
Rain6 (September)	−.01405*	.00515	−.01505*	.00365
Soil				
CC (Clay-chalk)	−.19559*	.04080	−.10966*	.03085
G (Gravel)	.10374	.07127	.23581*	.05845
GS (Gravel-sand)	.10555*	.04859	−.11840*	.03850
S (Sand)	−.10833	.06644	−.3933*	.04986
N (Nitrogen)	−.37259*	.07541	−.00916	.06730
P (Phosphoric acid)	.39005*	.07625	.01990	.06917
CaO (Lime)	−.15198*	.05453	−.18424*	.04023
MgO (Magnesia)	−.09609	.06797	.20228*	.05265
Fert (Fertilizer)	.04647	.03744	.07673*	.03183
Grape varieties				
Cabs (Cabernet-Sauvignon)	−.00287	.00506	−.00372	.00369
Merl (Merlot)	−.00688	.00550	.00170	.00396
Cabf (Cabernet Franc)	.00384	.00640	.00574	.00467
Other	.00000	–	.00000	–
Exposure				
E (East)	.39080*	.03917	.08180*	.03383
SE (South-East)	−.06565*	.03727	.07032*	.02810
S (South)	−.00020	.03257	−.00650	.02549
SW (South-West)	.10390*	.03946	−.02494	.02914
W (West)	−.20375*	.04371	−.03018	.03520
Age of vines				
Age1 (5 to 10 years old)	−.44537*	.13161	.13916	.10168
Age2 (10 to 20 years old)	−.19633*	.05990	−.21043*	.04388
Age3 (20 to 30 years old)	−.05862	.03799	−.08860*	.02890
Age4 (30 to 40 years old)	.11799*	.03751	.04791	.03112
Age5 (40 to 50 years old)	.14544*	.05645	.02419	.04328
Age6 (over 50 years old)	.28316*	.08614	.02655	.07334
Vinification and élevage				
Picking and selecting				
Pick (Manual picking)	.01038*	.03736	−.07041*	.02967
Sort (Manual sorting)	.20577*	.06747	.32563*	.05219

Continued

Table 1 (*Cont.*)

Variables	*Restr. Regression*		*Full regression*	
	Coeff.	*St. err.*	*Coeff.*	*St. err.*
Destemming and crushing				
Crush (Crush. before destemm.)	.22656*	.03609	.01929	.02817
Heat (heating of the moût)	.00724	.08060	.06331	.06089
Fermentation				
Ofloat (Open floating)	−.28112*	.04111	−.12965*	.03295
Closed (Closed tank)	.00000	–	.00000	–
Osub (Open submerged)	.59322*	.08972	.55887*	.07109
Npress (number of pressings)	−.09583	.05573	−.08788*	.04315
Nonoak (Oak *and* nonoak barrels)	−.44536*	.10698	−.34088*	.08462
Nrack (Number of rackings)	−.03084*	.01450	.02671*	.01175
Filtration				
Kies (Kieselguhr filter)	−.18337*	.06229	−.19386*	.04658
Asbest (Cell.-asb. filter)	−.02904	.03822	−.02441	.02949
Ads (Adsorption)	.10139	.07537	.17299*	.05712
Fresh (Fresh egg whites)	.24025*	.03764	−.00572	.03080
Time (Aging in casks)	.04635*	.00533	.01174*	.00409
Appellations				
Margaux	−.01789	.11088	.02868	.08415
Moulis-Listrac	.00000	–	.00000	–
Pauillac	−.19190	.11856	−.43516*	.09323
Saint-Estèphe	−.32571*	.11904	−.18536*	.08753
Saint-Julien	−.21740	.13405	−.24914*	.10448
Aging in bottles				
Margaux	.02848	.01621	.02264*	.01151
Moulis-Listrac	.00000	–	.00000	–
Pauillac	.03855*	.01128	.03986*	.01591
Saint-Estèphe	.00944	.01741	.00689	.01234
Saint-Julien	.03880*	.01856	.03214*	.01322
1855 Classification rents				
Margaux				
First-Growth			.90496*	.15600
Second-Growth			.18160*	.07506
Third- to Fifth-Growth			.28916*	.05888
All other			.00000	–
Moulis-Listrac				
All other			.00000	–
Pauillac				
First-Growth			2.05940*	.09107
Second-Growth			.98416*	.07920
Third- to Fifth-Growth			.51329*	.06411
All other			.00000	–
Saint-Estèphe				
Second-Growth[1]			.86822*	.11287
Third- to Fifth-Growth			.09108	.07098
All other			.00000	–

Continued

Table 1 (*Cont.*)

Variables	*Restr. Regression*		*Full regression*	
	Coeff.	*St. err.*	*Coeff.*	*St. err.*
Saint-Julien				
Second-Growth[1]			.87100*	.06851
Third- to Fifth-Growth			.60398*	.07630
All other			.00000	–
Intercept	24.285*	6.3662	25.46500*	4.5101
***R*-square**	.6765		.8403	
Adj. *R*-square	.6534		.8266	
Variance of the estimate	.1215		.0608	
Number of observations	808		808	
Number of degrees of freedom	754		744	

*means significantly different from zero at the 5% probability level at least.
[1]There are no First-Growth wines for Saint-Estèphe or Saint-Julien.

average maximum temperatures from June to September) and rainfall (variables *Rain3* to *Rain6,* measuring the excess or deficit of rainfall with respect to average rainfall during the same months). More heat is useful in June, since it accelerates blossoming (*Temp3* is positive); too much heat in July, August and September may have negative results (*Temp4* to *Temp6* are negative). In June and July, vines need rain (*Rain3* and *Rain4* are positive), while, later in the year, too much rain is bad, especially in September, before or during the harvest (*Rain5* and *Rain6* are negative). Note that all these variables (with the exception of *Rain3*) have an effect that is (in most cases very) significantly different from zero.

B. Soil

In the Médoc region, soils range from heavy clay to light gravels. One usually distinguishes four types of soil, present in various proportions: clay-chalky, gravelly, gravel-sandy and sandy. Some soils are better than others and deep gravel beds (like in Pauillac) seem to be the best, though there are outstanding wines produced in the much poorer gravel-sandy region of Margaux. Subtle differences in soil may lead to very different styles; however, "(soil) is not, as the Bordelais would have one believe, the only element necessary to make a great wine" (Parker, 1985, p. 505).

Besides soil density, chemical composition also plays an important role; we singled out four chemical components thought to be essential: nitrogen, phosphoric acid, lime and magnesia. Though fertilizer is kept to a minimum, it is used to maintain the complex mineral and chemical equilibrium.

These various characteristics are measured by four soil variables (*CC, G, GS* and *S* for clay-chalk, gravel, gravel-sand and sand respectively, which take the value 1 if the type is present, 0 otherwise), four chemical components (*N, P, CaO* and *MgO*

for nitrogen, phosphoric acid, lime and magnesia respectively, which are also dummy variables) and a last dummy variable *Fert*, equal to 1 when fertilizer is used.

The estimation results show that, as expected, gravelly and gravelly-sandy soils have a positive impact, while sandy and clay-chalky soils have a negative (and, for the latter significant) impact. Nitrogen and phosphoric acid have the expected sign,[4] and their effect is significantly different from zero. Lime and magnesia are "bad" (significantly so for lime). Finally, fertilizing has also a positive (but not significant) influence, since it appears to be used sparingly, and only when really needed.

C. Grape Varieties

Médoc wines result from a combination of five varieties of grapes used in varying proportions: Cabernet Sauvignon (40 to 85%), Merlot (5 to 45%), Cabernet Franc (0 to 30%), Petit Verdot (3 to 8%) and Malbec, in small proportions (less than 2%). These varieties ripen and are harvested at different times; weather conditions at certain moments may thus influence some vineyards more than others, in accordance with the grape varieties used. Clearly, each variety has its own influence on the characteristics of wines: Cabernet Sauvignon is poor in sugar, the richest in tannin, and allows wines to age; Merlot, the first to ripen is less tannic and richer in sugar than Cabernet Sauvignon; this makes the association of both varieties very attractive. Cabernet Franc ripens earlier than Cabernet Sauvignon, adds bouquet and tends to produce lighter wines; Petit Verdot ripens late (and is therefore used only in small proportions), is very tannic and rich in sugar, adding alcohol to the wine; Malbec is being replaced more and more by Merlot, with which it shares the same qualities. It is worth noting that grape varieties may lead to different outcomes according to the type of soil on which they are grown.

Grape varieties are represented by four variables (*Cabs, Merl, Cabf, Oth* for Cabernet Sauvignon, Merlot, Cabernet Franc and Other[5]) measuring the excess (or deficit) of the proportion used by the château with respect to the average use by the 102 châteaux. None of the variables has a significant influence: small variations in grape varieties do not seem to matter too much.

D. Exposure

Though Parker (1985) does not discuss exposure, we included it among our variables. Slopes exposed to the East and the Southeast are protected from Western winds, dominant in the region; moreover, the rising sun quickly dries the dew, and

[4] Nitrogen, which favors vegetation, has a negative impact; its excess is corrected by the presence of phosphoric acid.

[5] To avoid multicollinearity, *Other* (which includes Petit Verdot and Malbec) is left out from the regression.

reduces the risk for grapes to go rotten. Western slopes are usually closer to the river Garonne, and are more likely to have a gravelly soil; moreover, there is light reflection from the river over the slopes.

These characteristics are represented by dummy variables, which take the value 1 if the château possesses slopes with a given exposure. We included five variables, *E, SE, S, SW* and *W* for Eastern, Southeastern, Southern, Southwestern and Western exposures respectively.[6] Estimation results show that especially Eastern and to a lesser extent, Southwestern exposures have a significant positive effect; Western slopes are bad, while other exposures have small (and not significantly different from zero) negative effects.

E. Age of Vines

Old vines produce less, but a wine of better quality; Mouton-Rothschild vines are, on average, 43 years old; so are the vines at Lafite-Rothschild, another Pauillac First-Growth. At first sight, age does not seem to be necessary: Pichon Lalande, classified as a First-Growth by Parker, has vines the average age of which is 22 years only.

The age of the vines is represented by six dummy variables, *Age1* to *Age6*, which take the value 1 if vines of *Agei* are present, and the value 0 otherwise.[7,8] Despite the preceding remarks, the six coefficients clearly point out that age matters a lot: they are negative for young vines, and monotonically increase, as the vines get older. All the coefficients are strongly significant.

F. Vinification and Élevage

We now follow the production process through the eight steps distinguished by Parker (1985): (1) picking (and selecting), (2) destemming and crushing, (3) pumping into fermentation tanks, (4) fermenting of grape sugar into alcohol, (5) macerating or keeping the grape skins and pips in contact with the grape juice for additional extract and color, (6) pressing and racking or transferring the wine to small barrels (or tanks) for the secondary (malolactic) fermentation to be completed, (7) putting the wine in oak barrels for aging and (8) bottling the wine.

[6] For a given château, several of the variables may be equal to 1, if vines are grown on different types of slopes.

[7] *Age1* = 1 for 5 to 10 years old vines; *Age2* = 1 for 10 to 20 years old vines; *Age3* = 1 for 20 to 30 years old vines; *Age4* = 1 for 30 to 40 years old vines; *Age5* = 1 for 40 to 50 years old vines; and *Age6* = 1 for vines older than 50 years. In general, there will thus be several variables equal to 1 for a château.

[8] An alternative would have been to calculate an average age of vines for every château; our questionnaire was not put up under that form, and Parker (1985) does not provide this information for all the châteaux.

(1) Picking and selecting

Harvesting usually starts after September 15 and may take as long as three weeks. Manual picking is disappearing, since it costs more and may take too long; automatic picking is faster, allows thus to harvest at the right maturity, but may damage grapes and mix more stems than needed. In most cases, both methods are used, but some châteaux still resort to manual picking exclusively; a dummy variable *Pick* is defined which takes the value 1 if only manual picking is used. As expected, it has a positive effect on prices, which is however not significantly different from zero.

Whether the picking is manual or not, grapes must be selected (this is called *triage*): damaged, unripe or rotten berries must be eliminated, before the crushing process. Most châteaux instruct their pickers to eliminate unhealthy grapes; some châteaux still sort grapes by hand, after the picking. In such cases, a dummy variable *Sort* takes the value 1. The results show that its coefficient is positive, and significantly so.

(2) Destemming and crushing

In most châteaux, crushing the berries and destemming[9] is done simultaneously in a machine called *fouloir égrappoir*. Some vineyards still use the older technique of crushing before destemming. A dummy variable *Crush* takes the value 1 when this is the case (and 0 otherwise); as expected, its effect is positive, and significant.

(3) Pumping into fermentation vats

The partially crushed berries are then pumped into vats and fermentation can start. Several chemical decisions have to be made at this point; these consist in: adding sulfite (*sulfitage* has many complex effects and is practiced by all châteaux); chaptalizing (*chaptalization*, i.e., adding sugar, increases the alcohol content and is used by most châteaux, when needed); acidifying or deacidifying (*acidification* and *deacidification* are not practiced, and only seldom allowed); adding yeast (*levurage*) is used to start the fermentation process if it does not happen spontaneously; used by all châteaux). Since all vineyards proceed in the same way, there was no way to capture the possible effects of these chemical steps.

(4) Fermenting of grape sugar into alcohol

Several types of tanks are used: oak, cement and stainless steel. During fermentation, temperature has to stay within tight bounds, usually between 25° and 30 °C: fermentation does not start if the temperature is too low, while acetic

[9] Destemming may be total or partial, since stems and pips add tannin. Most châteaux destem totally.

bacteria may grow and natural yeasts will be destroyed (and stop fermentation) if temperature gets too high. This severe monitoring is easier to achieve in stainless steel tanks, by running cool water over the outside of the tanks; in the two other cases (oak and concrete tanks), wine must be run through cooling tubes; oak vats, on the other hand, are more natural and allow wood components to mix with the wine. Since most châteaux use stainless steel, we did not include the variables in our regressions.

The crushed grapes are in some cases mixed with heated *moût;* this step, represented by the variable *Heat* (a dummy which takes the value 1 if heating is used) is supposed to free coloring and some other components; this step appears to have no significant influence.

During fermentation, skins, stems and pips rise to the top of the tank and form a solid cap (the *chapeau*), which must be kept moist by pumping the wine juice over it (*remontage*). Three techniques are available to achieve this: open tank with floating marc (represented by a dummy variable *Ofloat*); closed tank (a dummy not included, since only one of the techniques is being used); open tank with submerged marc (variable *Osub*). The first technique allows a contact with air that may oxidize (and infect) the wine, and it needs a *remontage*. Both problems are avoided with the third technique; with the second one, oxidation is avoided, but since temperature may increase too much, a remontage (and thus, a contact with air) may be needed. This is clearly reflected in our results, which very significantly rank the three techniques, showing that the third one is the best.

(5) Maceration

After the alcoholic fermentation is completed, the wine is macerated with the skins during one to two weeks. The length of this period is crucial for the wine, but since most châteaux do more or less the same, we did not include the variable.

(6) Pressing and racking

After steps (4) and (5) which constitute the *cuvaison*, the wine is separated from its lees (*lie* and *marc*); the free-run juice (*vin de goutte*) is the wine of better quality; the remainder is then pressed one or several times, resulting in press-wine (*vin de presse*) which is more pigmented and tannic than the free-run juice. Some press-wine (the proportion depends on the year and the château) is then blended with the free-juice to adjust color and tannin.

Several types of presses exist, but have no influence on the quality of the wine. Quality is however negatively influenced by the number of pressings; to test this, we constructed a variable *Npress* which takes the value 1 if there is only one or two pressings, and the value 0 if there are more; the regression coefficient is negative and almost significantly different from zero. Note that this should not be taken as evidence against too many pressings since, even when more than two

pressings are performed, only a small percentage (which varies over the vintages) of the press-wine is blended and the number of pressings has no real bearing on quality.[10]

(7) Aging in barrels and racking

The young wine is then transferred to 225 liter barrels (where the alcoholic fermentation may be pursued) and the secondary (or malolactic) fermentation, which adds roundness and character, starts and lasts for three to five months.

Most châteaux use (a mix of old and new[11]) oak barrels; some Crus Bourgeois use both oak barrels and tanks. When this is the case, the variable *Nonoak* takes the value 1. The coefficient is, as expected, strongly negative and statistically different from 0.

Aging in barrels varies between 12 and 24 months (depending on the vintage), during which a number of steps have to be taken.

First, the wine evaporates and produces carbon dioxide; this empties the casks, which have to be refilled every week (*ouillage*); all châteaux carry out this step.

Secondly, the wine is racked (*soutirage*) several times during the first year, to separate the clear wine from the lees (*lie*) which have fallen to the bottom of the cask; we introduced a variable *Nrack* representing the number of rackings; the coefficient which it picks is negative and significant at the 5% level: this is contrary to what is expected, since more rackings should increase quality, at the risk, however of oxidizing the wine through contact with air.

Thirdly, all châteaux carry out a procedure, which cleans the wine from, suspended matter; this is the fining of the wine (*collage*) that is achieved with egg whites, fresh or not. A variable *Fresh*, which takes the value 1 when fresh egg whites are used, captures the influence; as is seen in Table 1, freshness has a strong positive effect.[12]

The number of months during which the wines age in barrels may vary. The regression coefficient associated with this variable (*Time*) is positive and significantly so. Each extra month adds approximately 5% to the price of a wine.[13]

[10] Only 28 of our châteaux press once and 12 of these are Crus Bourgeois; in Pauillac, there is often only one pressing, since the free-juice is already sufficiently colored and tannic.

[11] Whether the barrels have to be new or old is a hotly debated issue; we had little information on this and could not take it into account in our regressions.

[12] Fining can also be achieved with bentonite or gelatine. This was the case only once or twice in our sample, and we included the cases among "nonfresh."

[13] The relation is probably nonlinear, and there should be an optimal number of months; but this did not come out from our regressions.

(8) Bottling the wine

In January following the vintage, most châteaux carefully select the wine which is going to be bottled under the château's name, while the remainder will be sold under secondary labels, or in other ways. At the same time, wines resulting from different vines are blended (*assemblage*). Since these two steps are impossible to quantify (and because they are used in most places) they are not included in our analysis.

Before bottling takes place, wines are filtered,[14] in order to remove solid matters. There are two filtration techniques that proceed mechanically (one uses kieselguhr, the other cellulosic-asbestos filtering components); a third process proceeds by adsorption. The particularity is that adsorption needs one of the two other processes, while each of the mechanical processes can be used on its own. To represent this technology, we introduce three dummy variables: *Kies, Asbest* and *Ads* which take the value 1 if the technique is used, 0 otherwise. The effect of kieselguhr filtration alone is significantly negative; asbestos filtering has a slightly negative, but insignificant, effect; the use of adsorption (necessarily associated with one of the other two processes) yields better results, especially when associated with asbestos filtration.[15]

G. The Influence of Appellations

In the preceding sections, we tried to describe and analyze as many technical and other characteristics as possible; most of them had a significant influence on the price (quality) of the wine. In this section, we assume that there may be characteristics which describe the region of production (*appellations*), and which have not been adequately taken into account before. These are simply dummy variables, which take the value 1 if the château belongs to a specific region (Margaux, Moulis-Listrac, Pauillac, Saint-Estèphe and Saint-Julien), and 0 otherwise. Except for Saint-Estèphe, the coefficients are not significantly different from 0, but they are all negative (with respect to Moulis-Listrac chosen as reference). Clearly, this does not imply that the price (quality) of a Moulis is higher than the price of a Pauillac, but that, if all other characteristics (vines, soil, techniques, etc.) were the same, Moulis-Listrac châteaux would be able to charge higher prices for their wines. Are they more efficient, or do they simply benefit from the reputation of their prestigious Haut-Médoc neighbors, which allows them to slightly overprice the qualities implied by their characteristics?

[14] Note that some châteaux filter the wine before élevage starts.

[15] Note that First-Growths never filter their wine, and only 3 Second-Growths do so; other Growth-wines use asbestos filtering, with or without adsorption; Crus Bourgeois use kieselguhr filters exclusively.

H. Aging in Bottles

To determine how age influences prices, we introduced for every appellation a variable that takes the value 1990-t, where t goes from 1989 to 1980; the variable simply gives the age of the wine, relative to the vintage year. Since one of the variables has to be excluded for collinearity reasons (here Moulis-Listrac), the annual growth rates of prices captured by the regression coefficients are relative to the growth rate of Moulis-Listrac prices, assumed to be zero. As is seen from Table 1, all the coefficients are positive, implying that aging adds more to prices of Margaux, Pauillac, Saint-Estèphe and Saint-Julien than to prices of Moulis-Listrac wines. Only the coefficient for Saint-Estèphe is not significantly different from 0. Wines that take most value in aging are, as expected, those from the Pauillac region (+4% per year); these are followed by Saint-Juliens (+3.9%) and Margaux (+2.8%).

IV. The Effects of the 1855 Classification

In 1855, the wines of Médoc were classified; at that time, 60 châteaux were selected and classified as First to Fifth-Growth on the basis of their quality; the only change since was made in 1973, when Mouton-Rothschild was elevated to a First-Growth wine (See Appendix 1 for the classification). We now examine whether, beside all the characteristics discussed above, classification matters. To test this, we have run a second regression (the "full regression" of Table 1), where we have included variables representing, at least in part, this classification. More precisely, we have distinguished four classes: First-Growths, Second-Growths, Third- to Fifth-Growths and all other wines (Crus Bourgeois and unclassified),[16] and this for each of the regions. When a wine belongs to one of these subclasses (class times region), a specific dummy variable takes the value 1. This adds ten dummy variables to the previous regression.

As can be seen from the results in Table 1 ("full regression"), the fit has been made dramatically better, since now 84% of the variance of prices is explained, compared to 67% in the previous one. The two regressions can easily be compared using a standard F-test statistic:

$$[(SSR-SSF)/p]/[SSF/(n-p-q)] \quad (1)$$

where SSF and SSR represent the residual sum of squares of the full and the restricted equations respectively, n is the number of observations, p the number of variables left out of the restricted equation and $p+q$, the number of variables in the full equation.

[16] To avoid too many classes, we aggregated Third-, Fourth- and Fifth-Growth wines into one class and all Crus Bourgeois or unclassified into another one.

Under the usual assumptions (normally and identically distributed residuals), this ratio is distributed like F, with p and $n-p-q$ degrees of freedom. The computed F, with $p=10$ and $n-p-q=744$ degrees of freedom is equal to 76.3, while the tabulated value is equal to 2.5 at the 1% probability level.[17] The classification variables add thus very significantly to the explanation of prices.

And indeed, all the coefficients (with the exception of Third- to Fifth-Growth Saint-Estèphe) are positive and very significantly different from zero. The technical variables described earlier are far from explaining the differences in qualities (prices) and most classified châteaux are able to benefit from the title of nobility they were given in 1855. These differences may however also be attributed to technical aspects which are not part of the rather simple technology that is described by our variables; it is certainly the case that there is more work, care and genius put into Mouton-Rothschild than into a Cru Bourgeois, and the effect captured by the dummies cannot exclusively be interpreted as pure rents accruing to some châteaux as a mere consequence of the 1855 classification.

The wines from Pauillac illustrate that differences may be large; the mere fact that Mouton-Rothschild, Lafite-Rothschild and Latour are First-Growth adds 2.0594 to the logarithm of the price, i.e., it permits the three châteaux to multiply their prices by 7.8, with respect to a Cru Bourgeois from the same region, all other things being equal.

First-Growths are able to do better than Second-Growth, Second-Growth do better than Third- to Fifth-Growths and the latter do better than Crus Bourgeois. There is one exception for Margaux, where the order between Second and Third- to Fifth-Growths is inversed. Even if the differences seem to be high in absolute value (especially for First-Growth Pauillac's), the order just described is the one to expect.

Note that addition of the classification variables changes some of the technical coefficients discussed in the previous section: it mainly affects the soil and the age of vines effects, as well as the signs of the *Pick, Nrack* and *Fresh* coefficients. The classification is thus not fully exogenous, but is obviously partly explained by characteristics of the vineyards in 1855.

To test this, we ran binomial probit analyses,[18] in which the dichotomous dependent variable takes the value one for a 1855 classified wine, and zero otherwise. In a first model, the explanatory variables are assumed to represent the endowment of the châteaux at the time the classification was set up: soil

[17] Again, if the residuals are non-spherical, we may be led to wrongly reject the null hypothesis; but as can be checked, the computed F variable is so large, that there is little doubt about the classification variables being important.

[18] Since there are more than two classes, a polytomous model may appear better suited. However, given the number of observations (102 châteaux), and the reduced number of observations in some of the classes (there are for instance only four First-Growths in the 1855 classification), the results could be misleading.

Table 2
Probit Analyses

	Model 1	*Model 2*
Log. of the likelihood function	− 54.7	− 19.9
Likelihood ratio test	31.9	101.5
Degrees of freedom	13	37
Cragg-Uhler pseudo *R*-square*	.358	.840
Number of correct predictions	77	92

* See G. Maddala (1985), p. 40.

characteristics and exposure (in principle the 1855 endowment, though some changes may have happened since); all other variables (grape varieties, age of vines, vinification) are likely to have undergone changes over the 135 years;[19] these are only added in a second model.

The results of these two regressions are summarized in Table 2. The first model shows that the 1855-endowment (soil and exposures) is able to account for 77 right predictions, on a total of 102 cases. In the second model, the number of right predictions is 91.[20] A likelihood ratio test shows that the second model is significantly superior to the first (the quantity $-2\log(L_2-L_1)$ distributed like χ^2 with 24 degrees of freedom is equal to 69.5).

This analysis leads to several conclusions. The (assumed) 1855 endowment has, as expected, a high discriminatory power in classifying Growth-wines. This power is significantly enhanced when variables describing today's technological processes[21] are introduced; here one is led to argue that causality is reversed: the châteaux that were classified in 1855 (on the basis of their prices), work harder to maintain their reputation and produce first-class wines.

In order to compare the different wines, we must take into account both the appellation and the classification effects, so that all châteaux can be ranked with respect to the reference, a Cru Bourgeois from Moulis-Listrac; to do this, we have to add the coefficients taken by the appellation and the classification effects; thus, comparing a First-Growth Pauillac with a Moulis-Listrac, implies adding − .43516 (appellation effect of Pauillac) to 2.05940 (First-Growth effect of a Pauillac) and compare this with 0 (Cru Bourgeois from Moulis-Listrac). These computations are presented in Table 3, both for a young wine (age 0) and a ten year-old wine, the coefficient of which is obtained by adding 10 times the "aging in bottle" effect. The coefficients are also transformed into indices with, as basis, 100 for a Moulis-Listrac.

[19] Note that even soil and exposure may have changed since 1855.
[20] See Appendix 2 for the list of wrong predictions generated by the two models.
[21] Obviously, some of these characteristics may also have been effective in 1855.

Table 3
Total "Rents" Captured by the Various Châteaux Young and 10 year old wines

	Regression coefficients		*Indices (Moulis = 100)*	
Appellation	*Young wine*	*10 year old*	*Young wine*	*10 year old*
Margaux				
First-Growth	.93364	1.16004	255	319
Second-Growth	.21028	.43668	123	155
Third- to Fifth-Growth	.31784	.54424	137	172
All other	.02868	.25508	103	129
Moulis-Listrac				
All	.00000	.00000	100	100
Pauillac				
First-Growth	1.62424	2.02284	508	756
Second-Growth	.54900	.94760	173	258
Third- to Fifth-Growth	.07813	.47673	108	161
All other	−.43516	−.03656	65	96
Saint-Estèphe				
Second-Growth	.68286	.75176	198	212
Third- to Fifth-Growth	−.09428	−.02538	91	97
All other	−.18536	−.11646	83	89
Saint-Julien				
Second-Growth	.62186	.94326	186	257
Third- to Fifth-Growth	.35484	.67624	142	197
All other	−.24914	.07226	78	107

Though age has differential effects on the various appellations, the ranking for young wines and ten year-old wines is practically the same; this is obviously due to the fact that rents resulting from aging (which are in fact mainly due to the content in tannin) are roughly equivalent for all wines, at least within a ten-year span.

V. Summarizing the Making of Wine

In this section, we summarize and try to understand which factors explain the quality (price) of Médoc wines. To do this, we start with the full regression, then delete the various factors (i.e., all the variables defining these factors) one at a time: climate, soil, grape varieties, exposure of the vineyards, age of the vines, wine making technique (here we distinguish the steps which take place before fermentation starts – such as picking, sorting and crushing the grapes - and the steps which take place during and after fermentation in casks), appellations, classification and aging in bottles. Standard analysis of variance techniques (see (1) above) will suggest what is important, and what is less so. Obviously, this does not mean that the factors that contribute less are not meaningful: they may be part of a

Table 4
Importance of the Factors. Analyses of Variance

	Residual sum of squares	*Degrees of freedom*	*F-statistic computed*	*tabulated (5%)*
All variables	45.232	64		
All variable but				
Climate	64.925	9	36.00	2.43
Soil	51.801	9	12.00	2.43
Grape varieties	47.350	3	11.61	3.78
Exposure	46.120	5	2.92	3.02
Age of vines	48.149	6	8.00	2.80
Picking, selecting, crushing	47.763	3	13.88	3.78
All other vinification	53.538	11	12.42	2.24
Both together (vinification)	56.761	14	13.54	2.07
Appellations	47.312	4	8.55	3.32
Classification	91.644	10	76.33	2.32
Both together	93.276	14	56.44	2.07
Aging in bottles	46.278	4	4.30	3.32
Soil, grape varieties, exposure age of vines, and vinification	71.523	37	11.70	1.61

production process and are therefore unavoidable (obviously, there is no wine without soil!), or they may contribute jointly with other factors.[22]

The results of the various analyses of variance are reproduced in Table 4, which gives the residual variance of each regression, the number of degrees of freedom picked up by the variables which are left out (the restricted model), and compares the computed F-statistic with the tabulated value at the 5% probability level.

As had already been pointed out earlier, the 1855 classification of wines into Growths is extremely important: it is in fact, the single factor which explains most; there is little doubt that classification partly captures the influence of missing variables (mainly qualitative: the "art" of winemaking), but obviously it also allows producers to seek rents, as suggested in Section IV.

The fact that climate constitutes the second more important set of variables will come as no surprise: there are good and bad vintages, that depend almost solely on the weather, and there is no need to comment on this any further.

Soil, grape varieties (though none of the variables in the group has a significant influence in Table 1) and vinification, both mechanical and chemical, come next. These are followed by appellations and the age of vines.

[22] Testing this would necessitate introducing cross-effects, a topic we did not pursue here.

Then comes aging in bottles; and this is quite surprising since aging is so thoroughly discussed in books and by wine critics. One of the reasons for this may be due to the functional form chosen for the relation, in which prices are assumed to grow exponentially with age ($\log p = \alpha\,(1990 - t)$ + other variables), while in fact, the dependence should be concave (quality goes through a maximum). We did not pursue this here, since we are dealing with relatively young wines (10 years old at most), and we assumed that, given the quality of the châteaux included in our sample, ten year-old wines have not always had time to reach their maturity.

Finally, there is exposure, the dropping of which does not even affect the results in a significant way.[23] The reason for this may be that most châteaux own hills with different exposures, and take this into account in deciding where to grow the various grape varieties (which ripen at different times) and in the blending of their wines.

It may be thought that, after all, technical variables (soil, grape varieties, exposure, age of vines, and vinification in general) have no strong influence. The last analysis of variance of Table 4 shows that, as expected, this is far from being the case.

VI. Is the 1855 Classification Outdated?

The 1855 classification probably started to be disputed as early as 1856. It never was officially revised, and the only change that has been made since was the upgrading, in 1973, of Mouton-Rothschild.

Every wine specialist sets up his own classification; obviously, there are many good reasons for which the qualities of the wines may have changed between 1855 and 1990; moreover, the tastes of wine connoisseurs, wine tasters and wine amateurs may also have evolved over more than a century, and a wine which was thought of as great in 1855 may not be perceived so in 1990.

An interesting question is thus to examine whether contemporary classifications, like those compiled by Lichine (1963), Dussert-Gerber (1990) or Parker (1990)[24] are more prone to explain prices than the official 1855 classification. If Lichine or Parker is right, consumers will take the information into account and producers will be able (or forced) to pass on the increase (or decrease) of quality into prices. Then, such a classification should do better in explaining prices than the supposedly outdated 1855 classification.

If the assumption on passing quality into prices is correct, one may simply run the same regression but with new definitions for the classification dummies, and verify

[23] At the 1% probability level; it is significant at the 5% level (the tabulated F is equal to 2.21).
[24] Parker's 1990 classification (French edition) differs slightly from his 1985 classification (American edition). We used the more recent one. The Appendix gives his 1990 classification.

which classification leads to the best fit. We considered the Lichine classification to be too old (1963) to deal with 1980–1990 wines, and performed the computations with Dussert-Gerber's and Parker's classifications, which are both given in Appendix 1, and can be seen to be quite different from the 1855 classification.[25] The estimated coefficients for appellations and classifications as well as some summary statistics of the three regressions appear in Table 5.

There is only one "inversion" in the 1855 classification: Third- to Fifth-Growth Margaux are more expensive than Second-Growths; such anomalies appear three times in both Parker's and Dussert-Gerber's classifications, implying that there exist discrepancies between qualities (as defined by Parker or Dussert-Gerber) and prices. The 1855 classification leads also to the best fit (highest R-square[26]); however, while Parker's performance is quite close to that of the official classification, Dussert-Gerber's is much worse. It is thus tempting to conclude that, broadly speaking, the 1855 classification is still the one that is implicitly accepted by consumers.

Though there is no other choice when one has to compare more than two non-nested models, one may also compare the 1855 classification with either Parker or Dussert-Gerber, by embedding the competing models within a more general model:

$$y = Z\gamma + X_0\beta_0 + X_a\beta_a + u, \tag{2}$$

where Z is the matrix of technical variables, common to both the 1855 and the alternative model, X_0 is the matrix containing the 1855 classes and X_a the one containing the alternative classification. One then tests whether the alternative classification adds to the older one (or vice-versa), i.e., H_0: $\beta_a = 0$ (H_0':$\beta_0 = 0$). As is well known, such nesting may lead to reject both H_0 and H_0', and this is precisely what happens here for both pair-wise comparisons, as is shown in Table 6.[27]

Therefore, other criteria have to be taken into account, and indeed, the regression coefficients on the classification variables in model (2) may give indications. When there are only two classes and the two classifications are fully disjoint, it is easy to check that if classification 0 (resp. a) is the correct one, β_a (resp. β_0) will be equal to zero and β_0–β_a will be positive (resp. negative). In situations that are less simple (more then two classes and classifications which are not fully disjoint), the sign of β_0–β_a may still help in deciding which classification to choose.

[25] In our regressions, we have four classes: First-Growths, Second-Growths, Third- to Fifth-Growths and All other. With respect to these four classes, there are 32 (resp. 47) differences between Parker's (resp. Dussert-Gerber's) and the 1855 classification. There are many more if Third-, Fourth and Fifth-Growths are distinguished.

[26] Other criteria, such as Akaike or Schwarz would lead to the same conclusion here, since the number of degrees of freedom is the same in all three cases. See Gourieroux and Monfort (1989, Chapter 22).

[27] One should note however, that H_0' : $\beta_0 = 0$ is rejected much more strongly than H_0: $\beta_a = 0$. The 1855 classification is better supported by the price structure than alternative classifications.

Table 5
Comparison of Three Wine Classifications

	1855 classification		*Parker 1990*		*Dussert-Gerber*	
	Coeff.	*St. dev.*	*Coeff.*	*St. dev.*	*Coeff.*	*St. dev.*
Appellations						
Margaux	.0287	.0842	−.0029	.0919	.1110	.0988
Moulis-Listrac	.0000	–	.0000	–	.0000	–
Pauillac	−.4352*	.0932	−.4291*	.1004	−.2418*	.1083
Saint-Estèphe	−.1854*	.0875	−.5340*	.0977	−.2560*	.1065
Saint-Julien	−.2491*	.1045	−.7375*	.1155	−.2730*	.1169
Classifications						
Margaux						
First-Growth	.9049*	.1560	.6792*	.1096	−.0095	.0857
Second-Growth	.1816*	.0751	–	–	.1589*	.0756
Third- to Fifth-Growth	.2892*	.0589	.2618*	.0478	.2544*	.0681
Other	.0000	–	.0000	–	.0000	–
Moulis-Listrac						
Third- to Fifth-Growth	–	–	−.1817*	.0807	0.0199	.0780
Other	.0000	–	.0000	–	.0000	–
Pauillac						
First-Growth	2.059*	.0911	2.1856*	.1003	1.2626*	.0765
Second-Growth	.9842*	.0792	.3539*	.1169	.3723*	.1029
Third- to Fifth-Growth	.5133*	.0641	.4854*	.0609	.3406*	.0664
Other	.0000*	–	.0000	–	.0000	–
Saint-Estèphe						
First-Growth	–	–	–	–	.5352*	.1305
Second-Growth	.8682*	.1129	1.1784*	.1148	.3732*	.1080
Third- to Fifth-Growth	.0911*	.0710	.4342*	.0627	.1994*	.0578
Other	.0000	–	.0000	–	.0000*	–
Saint-Julien						
First-Growth	–	–	1.3576*	.0861	1.0217*	.0941
Second-Growth	.8710*	.0685	.5916*	.1175	.4856*	.0783
Third- to Fifth-Growth	.6040*	.0763	1.0783*	.0850	.4941*	.0984
Other	.0000	–	.0000	–	.0000	–
Goodness of fit						
R-square	.8403		.8329		.7989	
Adjusted *R*-square	.8266		.8183		.7807	
Variance of the estimate	.0608		.0637		.0769	

*means significantly different from zero at the 5% probability level at least.

Table 6
Embedding 1855 and the Alternative Model

Embedding	H_0	*F-test*
1855 and Parker	$\beta_a = 0$	16.8
1855 and Parker	$\beta_0 = 0$	23.7
1855 and D-G	$\beta_a = 0$	13.5
1855 and G-G	$\beta_0 = 0$	43.6

Table 7
Coefficients in the Embedded Models

	1855		*Alternative*	
	Coeff.	*St.dev.*	*Coeff.*	*St.dev*
1855-Parker				
Margaux				
First-Growth	.595	.170	.454	.128
Second-Growth	.514	.103	–	–
Third- to Fifth-Growth	.379	.080	−.107	.070
Moulis-Listrac				
Third- to Fifth-Growth	–	–	−.230	.076
Pauilllac				
First-Growth	1.831	.164	.527	.160
Second-Growth	.837	.121	−.027	.120
Third- to Fifth-Growth	.659	.082	.063	.082
Saint-Estèphe				
Second-Growth*	1.340	.110	–	–
Third- to Fifth-Growth	.212	.073	.238	.064
Saint-Julien				
First-Growth	–	–	1.532	.162
Second-Growth	−.167	.136	.896	.171
Third- to Fifth Growth	−.004	.094	1.102	.110
1855-Dussert-Gerber				
Margaux				
First-Growth**	1.162	.171	−.110	.084
Second-Growth	.344	.087	.134	.085
Third- to Fifth-Growth	.320	.058	.066	.053
Moulis-Listrac				
Third- to Fifth-Growth	–	–	.170	.070
Pauillac				
First-Growth	1.995	.122	.212	.093
Second-Growth	.851	.098	.176	.098
Third- to Fifth-Growth	.550	.077	.066	.068
Saint-Estèphe				
Second-Growth***	1.050	.110	.395	.102
Third- to Fifth-Growth	−.014	.078	.234	.054
Saint-Julien				
First-Growth	–	–	1.121	.112
Second-Growth	.228	.092	.585	.079
Third- to Fifth-Growth	.587	.072	.374	.093

* Montrose, the unique 1855 Second-Growth in our sample is also classified as such by Parker. **Dussert-Gerber classifies Château Margaux as HC; we assimilated to a First-Growth. ***Montrose is classified as a (unique) First-Growth by Dussert-Gerber. Since it is the only wine classified as Second-Growth in 1855, there is no variable corresponding to it in the D-G classification.

Table 7 displays the results, and, given the comments which precede, shows that Saint-Juliens and Third- to Fifth-Growth Saint-Estèphes are obviously misclassified in the 1855 classification (and this is corrected both by Parker and Dussert-Gerber);

Dussert-Gerber seems also to be doing better by upgrading some Moulis-Listrac wines.

We then proceeded as follows:

(1) We replaced the 1855 Saint-Julien classification and the 1855 Third- to Fifth-Growth Saint-Estèphe classification by Parker's and kept unchanged the remainder of the 1855 classification; embedding then the rest of Parker's classification and testing H_0: $\beta_a = 0$ leads to and *F*-value of 5.9, which is still significant, but much lower than the corresponding value of 16.8 in Table 6.

(2) Alternatively, we adopted Dussert-Gerber's classification for Saint-Julien First and Second Growths, for Saint-Estèphe Third- to Fifth-Growths and for Moulis-Mistrac Third- to Fifth-Growths; embedding then the rest of Dussert-Gerber's classification gives an *F*-value of 4.9, significant, but also much lower than the corresponding value of 16.2 in Table 6.

Both Parker and Dussert-Gerber seem thus to be right in correcting the 1855 classification for Saint-Juliens and Third- to Fifth-Growth Saint-Estèphes, mainly by upgrading; Dussert-Gerber also correctly upgrades some wines from Moulis-Listrac. On the other hand, none of them adds much by shifting Pauillac and Margaux wines for which the 1855 classification seems, by and large, still to be holding.

VII. Conclusions

Weather conditions are, as is often thought, the most important factor that contributes to quality, though the production technologies and the characteristics of the vineyards are far from being negligible in explaining differences across origins.

Reputation effects also convey very strong signals, and (almost) all châteaux mention that they were classified in 1855. Though First and Second-Growths wines should have a strong incentive to be more precise by signaling their rank, most châteaux[28] only mention their grading as "Grand Cru Classé en 1855," without the rank. There is little doubt that they assume consumers to know "who is who," and probably find inelegant and superfluous to give details.

[28] Note that first ranked châteaux are more inclined than others to give their rank. Latour (a First-Growth Pauillac), Margaux (the unique First-Growth Margaux) Dufort-Vivens, Rausan-Ségla, Rauzan-Gassies (three out of the five Second-Growth Margaux) and Léoville-Poyferré (one of the 5 Second-Growth Saint-Juliens) mention their rank. With the exception of Ducru-Beaucaillou and Léoville-Las-Cases (2 Second-Growth Saint-Juliens) who mention *nothing,* all other bottles carry the label "Grand Cru Classé en 1855" only.

Like in art, where names of painters are important, the label of a wine is obviously part of its "quality" which is passed on into its price. But why does the 1855 grading provide a better explanation of prices than more recent ratings?

One may think this to be the consequence of poorly informed consumers, whose unique information is the label. This is unlikely however: consumers of such expensive wines seek for more signals, and these are readily available in well-publicized books and journals. Clearly, consumers believe that the 1855 classification conveys more information than the ratings of wine specialists who, anyway, keep contradicting each other.

We are tempted to conclude that the 1855 classification still provides *the* quality signal. Together with the fact that 85% of the variance of (the log of) prices set by 100 among the best châteaux over 10 years can be explained by observable factors, seems to raise questions on the role of wine tasting specialists. After all, perhaps their unique contribution is (and should be) to keep producers on their toes: most wines classified in 1855 seem still to deserve their rank, while some wines from Saint-Julien, Saint-Estèphe and Moulis-Listrac which were either not classified or poorly ranked in 1855 have been moved up, and rightly so, by recent classifications. This is also in agreement with the suggestion made in Section IV, that châteaux which were classified in 1855 do their best not to move down the ladder.

Postscript April 2013

This paper was presented in 1992 at the Vineyard Data Quantification Society (VDQS) Verona Conference and received the First Prize *Domini Veneti*, that included 80 bottles of a nice (but very heavy) Amarone. The paper was translated into Italian, and the Cantina Sociale Valpolicella Negrar, of which Giuseppe Gaburro—at the time president of VDQS—was the chairman, published both the English and Italian versions in the form of a small and informal but very nice-looking booklet in 1993. Otherwise, the paper was never published, but, from time to time, I receive an email asking me to send it, and Stuart Landon and Constance Smith (1998) were among the few who were kind enough to cite it.

Among the members of the jury who gave the prize let me cite in alphabetic order: Orley Ashenfelter, whom I was meeting for the first time, plus a few VDQS old timers, Françoise Bourdon, Danielle Meulders (one of the judges of the 2012 Princeton Tasting), Marie-Claude Pichery (chair of the jury), Henri Serbat (the inventor of the VDQS), plus a few people who I did not know. The number of people in the jury (about 20) was larger than the number of those who came to listen to the paper when I gave it.

My co-authors are Muriel Monzak and Andras Monzak. Muriel, an economics student who wrote her last year's paper on this topic with me, became a pharmacist. Andras, her father, traveled at the time from one Haut-Medoc vineyard to the next,

collecting (at the time, unpublished) data and buying wine. The only treat in my life of a beautiful Château Margaux served with Pauillac lamb.

1992 is a long time ago, a time at which I probably did not know—at least I do not remember whether I knew this or not—that the 1855 Bordeaux classification was based on the prices that wines fetched at the time (e.g., Markham, 1998). The same was true for the classification of wines from the Mosel (Ashenfelter and Storchmann, 2010).

I found a couple of papers, plus a 2012 Ph.D. Dissertation chapter (On the causality, cause and consequence of returns to organizational status: Evidence from the *grands crus classés* of the Medoc) that went much deeper than my coauthors and I were able to go. We used prices as dependent variable to try to see whether the 1855 classification was still up-to-date, and concluded that "consumers believe that the 1855 classification conveys more information than the ratings of wine specialists who, anyway, keep contradicting each other." This is also the conclusion drawn by Landon and Smith: "the empirical evidence indicates that consumers consider a long-term reputation for quality to be a better signal of current quality than the more recent quality movements ... The 1855 classification [is still] a very successful predictor of quality." Kugler and Kugler (2010) reach a similar conclusion for Bordeaux wines sold in Switzerland.

Thompson and Mutkoski (2011) strongly disagree with that view. Their findings are based on ratings by Robert Parker (*The Wine Advocate*), Stephen Tanzer (*International Wine Cellar*) and *Wine Spectator* for vintages from 1970 to 2005. They conclude that "more than half of the 61 wines classified growths [in 1855] are misclassified, with some châteaux moving as many as three tiers upward or downward compared to the historical classification." Mike Steinberger (2005) titles his paper in *Slate Magazine* "How the most important rankings in wine became irrelevant."

The Liv-ex Bordeaux classification compiled by the British internet and phone-based wine exchange (London International Vintners Exchange) in March 2009, and revised in 2011 mimics the 1855 classification which was based on prices. It finds large (relative) differences between 1855 and 2011: Lynch Bages (a second growth), for instance, gains 38 positions, while Rauzan Gassies (a fifth growth) loses 40 positions between the two price lists.

In his, by all accounts, excellent first chapter of his dissertation, Malter (2012) concludes that "returns accrue mostly to the very elite and are relatively small at the lower echelons of the status hierarchy." But this quote is far from giving him full justice. Read his chapter. You will learn a lot about industrial organization and well-done econometrics. Obviously, a young man, but already a very wise one also: "Classifications," he writes, "have always been debatable."

There is also a growing debate about "terroir," which has obvious links with the above paper. Gergaud and Ginsburgh (2010) for red Bordeaux (the same as those

analyzed in this paper), as well as Cross, Plantiga and Stavins (2011) for wines from Oregon, show that terroir does not explain much. Ashenfelter and Storchmann (2010) show that the inverse holds for wines from the Mosel valley.

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Appendix 1: List of Wines and their Classification

	Classification			*Sample*		
	1855°	*Parker*	*D.G.*	*Our's*	*Parker's*	*Person visited*
Margaux						
Margaux	1G	1G	HC	Y	Y	Mr. Blanchard*
Brane-Cantenac	2G	5G	1G	Y	Y	Mr. Lurton**
Durfort-Vivens	2G	5G	2G	Y	Y	Mr. Lurton**
Lascombes	2G	4G	2G	Y	Y	Mr. Gobinau***
Rausan-Ségla	2G	4G	2G	Y	Y	Mr. Bruzaud***
Rauzan-Gassies	2G	5G	UN	Y	Y	Mr. Quie***
Boyd-Cantenac	3G	3G	3G	Y	Y	Mr. Guillemet***
Cantenac-Brown	3G	5G	3G	Y	Y	Mr. Aymar du Vivier***
Desmirail	3G	GB	UN	Y	Y	Mr. Lurton**
d'Issan	3G	3G	3G	Y	Y	Mr. Cruse***
Ferrière	3G	GB	UN	N	Y	not visited
Giscours	3G	3G	1G	Y	Y	Mr. Guillemet***
Kirwan	3G	5G	5G	Y	Y	Mr. Demezzo*
Malescot-Saint-Exupéry	3G	5G	3G	Y	Y	Mr. Zuger**
Marquis-d'Alesme-Becker	3G	BE	UN	Y	Y	Mr. Zuger**
Palmer	3G	1G	2G	Y	Y	Mr. Bouteiller***
Marquis-de-Terme	4G	5G	3G	Y	Y	Mr. Hugon***
Pouget	4G	5G	UN	Y	Y	Mr. Guillemet**
Prieuré-Lichine	4G	4G	4G	Y	Y	Mr. Birades*
Dauzac	5G	GB	UN	Y	Y	Mr. Chatellier***
du Tertre	5G	5G	UN	Y	Y	Mr. Gasqueton***
Bel-Air-Marquis d'Aligre	UN	CB	UN	N	Y	not visited
Canuet	UN	CB	UN	N	Y	not visited
d'Angludet	UN	UN	5G	Y	Y	Mr. Sichel***
Labégorce	UN	BE	UN	Y	Y	Mr. Condom**
Labégorce-Zédé	UN	BE	4G	Y	Y	Mr. Thienpont***
La Gurgue	UN	UN	UN	Y	Y	Mr. Villars***
La Tour-de-Mons	UN	GB	UN	Y	Y	Mr. Clauzel***
Pontac-Lynch	UN	UN	UN	Y	N	Mr. Bodon***
Siran	UN	BE	3G	Y	Y	Mrs. Miailhe**
Tayac	CB	CB	5G	Y	Y	Mr. Portet***
Moulis en Médoc						
Brillette	GB	5G	4G	Y	Y	Mr. Berthault**
Chasse-Spleen	BE	5G	UN	Y	Y	Mr. Villars***
Dutruch-Grand-Poujeaux	BE	BE	UN	Y	Y	Mr. Cordonnier**
Gressier-Grand-Poujeaux	UN	GB	UN	Y	Y	Mr. Marcellus**
Maucaillou	UN	5G	UN	Y	Y	Mr. Dourthe**
Poujeaux (Theil)	BE	5G	4G	Y	Y	Mr. Theil**
Listrac en Médoc						
Clarke	CB	GB	UN	Y	Y	Mr. Bonnin****
Fonréaud	CB	UN	UN	Y	N	Mr. Lalande***
Fourcas-Dupré	BE	BE	4G	Y	Y	Mr. Pages***
Fourcas-Hosten	BE	5G	4G	Y	Y	Mr. Barthe***
Lestage	CB	CB	5G	Y	Y	Mr. Lalande***
Pauillac						

Continued

Appendix 1 (*Cont.*)

	Classification			*Sample*		
	1855°	*Parker*	*D.G.*	*Our's*	*Parker's*	*Person visited*
Lafite-Rothschild	1G	1G	1G	Y	Y	Mr. Le Canu***
Latour	1G	1G	1G	Y	Y	Mr. Hare***
Mouton-Rothschild	1G	1G	1G	Y	Y	Mr. Sionneau***
Pichon-Longueville (de Lalande)	2G	1G	1G	Y	Y	Mr. Godin***
Pichon-Longueville Baron	2G	4G	3G	Y	Y	oenologist
Duhart-Milon-Rothschild	4G	5G	4G	Y	Y	Mr. Huguet****
Batailley	5G	5G	4G	Y	Y	Mr. Valade****
Clerc-Milon	5G	5G	3G	Y	Y	Mr. Sionneau***
Croizet-Bages	5G	GB	4G	N	Y	refused to answer
Grand-Puy-Ducasse	5G	5G	4G	Y	Y	Mr. Badiera***
Grand-Puy-Lacoste	5G	3G	2G	Y	Y	Mr. Borie**
Haut-Bages-Libéral	5G	5G	4G	Y	Y	Mr. Villars***
Haut-Batailley	5G	5G	2G	Y	Y	Mr. Borie**
Lynch-Bages	5G	2G	1G	Y	Y	oenologist
Lynch-Moussas	5G	UN	UN	Y	N	Mr. Valade****
Mouton-Baronne-Philippe	5G	5G	UN	Y	Y	Mr. Sionneau***
Pédesclaux	5G	UN	UN	Y	N	Mr. Jugla**
Pontet-Canet	5G	5G	2G	Y	Y	oenologist
Belle-Rose	CB	UN	UN	Y	N	Mr. Jugla**
Colombier-Monpelou	GB	UN	UN	Y	N	Mr. Jugla**
Fonbadet	UN	5G	4G	Y	Y	Mr. Peyronie**
Grand-Duroc-Milon	CB	UN	UN	Y	N	Mr. Jugla**
La Fleur-Milon	GB	UN	UN	Y	N	Mr. Gimenez**
La Tour-Pibran	UN	UN	UN	Y	N	Mr. Jugla**
Les Forts de Latour	UN	5G	3G	N	Y	not visited
Moulin des Carruades	UN	BE	UN	N	Y	not visited
Pibran	CB	UN	UN	Y	N	oenologist
Plantey	UN	UN	UN	Y	N	Mr. Fournier***
St-Estèphe						
Cos-d'Estournel	2G	1G	1G	N	Y	refused to answer
Montrose	2G	2G	1G	Y	Y	Mr. Charmolue
Calon-Ségur	3G	4G	2G	Y	Y	Mr. Capbern Gasqueton**
Lafon-Rochet	4G	5G	4G	Y	Y	Mr. Tesseron**
Cos-Labory	5G	CB	3G	Y	Y	Mrs. Audoy**
Beau-Site	BE	UN	UN	Y	N	Mr. Casteja**
Clauzet	UN	UN	UN	Y	N	Mr. Boisseau**
de Pez	CB	4G	4G	Y	Y	Mr. Dousson**
Haut-Marbuzet	BE	3G	2G	Y	Y	N***
Houissant	UN	UN	UN	Y	N	N
La Commanderie	UN	UN	UN	Y	N	Mr. Fournier***
Laffite-Carcasset	UN	UN	5G	Y	N	N
Le Boscq	UN	UN	UN	Y	Y	Mr. Durand**
Le Crock	BE	UN	4G	Y	N	N
Les-Ormes-de-Pez	GB	5G	4G	Y	Y	N
Leyssac	UN	UN	UN	Y	N	N

Continued

Appendix 1 (*Cont.*)

	Classification			*Sample*		
	1855°	*Parker*	*D.G.*	*Our's*	*Parker's*	*Person visited*
Meyney	BE	5G	4G	Y	Y	Mr. Payeur****
Phélan-Ségur	BE	BE	UN	Y	Y	Mr. Gardinier**
Pomys	UN	UN	UN	Y	N	Mr. Arnaud**
St-Estèphe	UN	UN	UN	Y	N	Mr. Arnaud**
Tour-des-Termes	UN	UN	UN	Y	N	N
Tronquoy-Lalande	GB	GB	4G	Y	Y	Mrs. Casteja**
Valrose	UN	UN	UN	Y	N	N
St-Julien						
Ducru-Beaucaillou	2G	1G	1G	Y	Y	Mr. Borie**
Gruaud-Larose	2G	1G	3G	Y	Y	Mr. Pauli***
Léoville-Las-Cases	2G	1G	1G	Y	Y	Mr. Depoizier***
Léoville-Poyferré	2G	4G	2G	Y	Y	Mr. Cuvelier***
Léoville-Barton	2G	2G	2G	Y	Y	Mr. Raoul***
Lagrange	3G	BE	UN	Y	Y	N***
Langoa-Barton	3G	3G	UN	Y	Y	Mr. Raoul***
Beychevelle	4G	3G	2G	Y	Y	Mr. Ruelle***
Branaire-Ducru	4G	3G	2G	Y	Y	Mr. Tapie***
Saint-Pierre-Sevestre	4G	4G	UN	Y	Y	Mr. Triaud***
Talbot	4G	3G	4G	Y	Y	Mr. Pujoz***
Du Glana	BE	BE	UN	Y	Y	Mr. Ardiley***
Gloria	UN	4G	2G	Y	Y	Mr. Triaud***
Hortevie	UN	BE	UN	N	Y	not visited
La Bridaine	UN	UN	UN	N	Y	not visited
Lalande	UN	UN	4G	Y	N	Mr. Ardiley***
Moulin-Riche	CB	UN	UN	Y	N	Mr. Cuvelier***
Terrey-Gros-Cailloux	UN	BE	UN	Y	Y	N***

Classification
HC: Better than 1G
1G: First-Growth
2G: Second-Growth
3G: Third-Growth
4G: Fourth-Growth
5G: Fifth-Growth
BE: Cru Grand Bourgeois Exceptionnel
GB: Cru Grand Bourgeois
CB: Cru Bourgeois
UN: Unclassified

°The 1855 classification concerns Growth wines only; Crus Bourgeois were classified in 1978.
*Chef de culture
**Owner of the château.
***Régisseur, director or administrator of the château.
****Maître de chai.

Appendix 2: Misclassifications

	1855–1	*1855–2*	*Parker*	*Dussert-Gerber*
Margaux				
Margaux	*1G	1G	1G	HC
Lascombes	*2G	2G	4G	2G
Rauzan-Gassies	*2G	2G	5G	UN
d'Issan	*3G	3G	3G	3G
Kirwan	*3G	3G	5G	5G
Malescot-Saint-Exupéry	3G	*3G	5G	3G
Marquis-d'Alesme-Becker	*3G	*3G	BE	UN
Pouget	4G	*4G	5G	UN
Dauzac	*5G	5G	GB	UN
La Gurgue	*UN	*UN	5G	UN
Pauillac				
Pichon-Longueville Baron	2G	*2G	5G	3G
Batailley	*5G	5G	5G	4G
Grand-Puy-Ducasse	5G	*5G	5G	4G
Grand-Puy-Lacoste	*5G	5G	3G	2G
Pedesclaux	*5G	5G	UN	UN
Fonbadet	*UN	UN	5G	4G
Grand-Duroc-Milon	*CB	CB	UN	UN
La Fleur-Milon	*GB	GB	UN	UN
Pibran	*CB	*CB	UN	*UN
St-Estèphe				
Beau-Site	*BE	BE	UN	UN
de Pez	*CB	*CB	4G	4G
Haut-Marbuzet	*BE	BE	3G	2G
Houissant	*UN	UN	UN	UN
Le Boscq	UN	*UN	UN	UN
Les-Ormes-de-Pez	*GB	*GB	5G	4G
Pomys	*UN	UN	UN	UN
St-Julien				
Gruaud-Larose	*2G	2G	1G	3G
Léoville-Poyferré	*2G	2G	4G	2G
Saint-Pierre-Sevestre	*4G	4G	4G	UN
Moulin-Riche	CB	*CB	UN	UN
Terrey-Gros-Cailloux	*UN	UN	BE	UN

Note. A * indicates a misclassification by the probit model w.r.t. the original classification.