Accurate prediction of wine quality and prices using satellite data

I want to submit an abstract for:
Conference Presentation

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Keywords
satellite data; weather; wine quality; wine rating; pricing

Research Question
This paper tackles the two key issues of (i) measuring wine quality and its relation with weather conditions, and (ii) wine pricing.

Methods
Data: satellite data, tasting notes and ratings, and market prices.
Methods: machine learning (to model the relation between weather data and ratings) and regression analyses.

Results
Ratings can accurately be estimated on the basis of satellite data. Contrary to experts' ratings they are not affected by individual preferences. They can be used to model wine prices.

Abstract
This paper tackles the two key issues of (i) measuring wine quality and its relation with weather conditions, and (ii) wine pricing.
wine pricing. This paper is thus related to the three most important topics identified in wine economics by Storchmann (2012). To estimate wine quality, we use an innovative approach based on an artificial intelligence model and very precise data from satellites. To model prices, we use a more classical methodology – hedonic regression, but our work is distinct on several dimensions and allows us to interpret the deviations between effective and predicted release prices. We focus on Bordeaux wines which represent the major part of the fine wine market (liv-ex.com).

Our database contains satellite data as well as ratings and prices on the primary and secondary markets. In Bordeaux, the primary market is called “en primeur”. It is organized as follows. After the harvest in year Y, the wines (still in barrel and thus not yet finished) are presented to wine critics between March and April of year Y+1 so that they can rate them. These are the “en primeur” ratings. Then the wines are put on sale between May and June of Y+1. When the wines are finished, they can be delivered to buyers. They then begin to be traded on the secondary market, at the beginning of Y+3. At this moment, wine critics taste the wines again and publish their final scores. Our sample contains ratings from three leading wine critics (The Wine Advocate, Vinous and James Suckling) and prices on the primary and secondary markets for a comprehensive sample of Bordeaux wines over the period 2004 to 2021.

Measuring the quality of a harvest is a major research topic in agricultural economics and, even more so, in wine economics. Indeed, the price of fine wines depends more on quality than on quantity (Masset & Weisskopf, 2022). As an example, the 2017 Bordeaux wines are selling for less than their 2016 and 2018 counterparts, even though 2017 had a severe frost and low quantities. But the quality of the 2016 and 2018 vintages is considered remarkable and superior to 2017. From a theoretical perspective, the drivers of quality are now well known. The famous professor and wine producer, Denis Dubourdieu has built a model based on five criteria that identify a great vintage (if all criteria are met), a very good one (if most are met), or a weaker one (if few or none of the criteria are met) (Dubourdieu, et al., 2021). This model is conceptually close to the one used by Ashenfelter (2008). In this seminal paper, Ashenfelter uses weather data to estimate the quality of a vintage in Bordeaux. He shows that as the years pass, the price of wine on the secondary market tends to converge to what his model predicts based on his quality estimate. These results show that, on the one hand, it is relatively easy to get an idea of the quality of a vintage by analyzing weather conditions, and, on the other hand, it is common for wines of a given vintage to be initially inefficiently priced on the primary market. Though, it is much more difficult to apply the same logic at the level of individual wines because weather data specific to each estate and vineyard do not exist. In the literature, the authors therefore rely on expert ratings to estimate the quality of individual wines when they are released on the primary market (see, e.g., Masset et al. (2015), Hekimoğlu & Kazaz (2020)). The major problems with this type of data are that experts may suffer from various biases (see, e.g., Cardebat et al. (2014) and Cardebat & Livat (2016)) and their ratings are known at the earliest shortly before and often even after the wines have been marketed. This means that ratings can only partially play their role of moderating the information asymmetry that intrinsically exists between producers and buyers (wholesalers, merchants, end customers).

Since wines do not pay cash flows, the approach that has been adopted to analyze and model their pricing is that of hedonic pricing (Rosen, 1974). The question of the relationship between quality and price has been the subject of particular interest. This can be explained by the nature of wine consumption, which is aimed at gustatory pleasure and depends to a large extent on the quality of the wine. In their seminal paper, Combris et al. (1997) show that objective characteristics (information on the label) correlate more strongly with price than quality measures. In a meta-analysis, Oczkowski & Doucouliagos (2014) identify “a moderate price-quality correlation, which suggests the existence of strategic buying opportunities for better informed consumers.” These results are consistent with the analyses of Ashenfelter (2008) and Masset et al. (2023) who describe a significant relationship between quality and price, but also deviations between release prices and fair prices estimated according to the model. These results question the efficiency of the primary market for fine wines.

This paper contributes to the literature on several dimensions. First, we propose an approach that allows quality to be estimated at both the macro (the entire vintage) and micro (individual wines) levels using satellite data. This has never been done before, and it allows a very fine estimation of the weather conditions and the sanitary state of the vines up to the exact date of the harvest. This method avoids the bias that can result from the use of expert ratings. Our approach also allows us to anticipate the release price on the primary market several months in advance (as soon as the harvest is done) and to update it according to the situation on the secondary wine market and the general economic conditions.

In addition, our data allows for complementary and original analyses. Having an objective and accurate measure of quality that can be used as a benchmark both at the level of an entire vintage and at the level of individual wines
offers opportunities to: (i) identify wines whose “en primeur” ratings systematically deviate from the quality estimated by the model; (ii) identify vintages that are either rated too low or too high as a whole by the majority of experts; and (iii) analyze the ability of experts to correct their errors when they publish their final ratings (i.e., based on the tasting of the wines when they start trading on the secondary market). We then analyze the deviations between the effective release prices and those predicted by the model. We examine whether deviations in ratings (points (i) and (ii) above) can explain price deviations. More generally, we analyze the deviations between fair price and effective release prices from two perspectives: at the time of the “en primeur” release (on the primary market); and over time (on the secondary market). At the primary market level, we examine the role of variables such as the release price of direct competitors and the release date. This allows us to control for strategic behaviors. At the secondary market level, our database allows us to investigate whether price deviations are narrowing over time. This contributes to the discussion of the efficiency, or rather inefficiency, of the wine market by distinguishing between the primary and secondary markets.

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