Title
Pricing of Wine Futures under Weather and Market Uncertainty

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Keywords
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Research Question
How can we explain the changes in the release price of wine futures? What are the influencing factors (temperatures during growing season, rainfall, market)?

Methods
We employ statistical regression methods for a comprehensive set of data collected through Liv-ex. We replicate the study both for explaining and predictive power.

Results
Our results demonstrate both an explaining and predictive power. A higher temperature during growing season and a higher Liv-ex 100 index increase the release price while rainfall decreases futures price.

Abstract
Pricing of Wine Futures under Weather and Market Uncertainty

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Abstract
This study examines the release price of wine futures and explains how they are influenced by weather and market fluctuations. It is known that a winemaker harvests grapes at the end of a summer season and crushes them in order to produce wine. Fine wines, such as those produced in Bordeaux, spend 18 to 24 months in barrels for a long aging process. This is an extensive period of time to tie up the winemaker's cash into a product that will not

generate revenues for approximately two years. Winemakers often sell these fines wines in advance in the form of wine futures. These wine futures are referred to as "en primeur" in Bordeaux, and they feature a popular marketing campaign in the first week of May in each calendar year.

Winemaker determines the initial release price of wine futures that begin to trade before the first summer following the harvest (approximately eight months after harvest). The wine does not even get bottled for another year. Buyers of wine futures receive their wine after the wine is bottled and is ready for retail and distribution. By selling wine early in the form of wine futures, a winemaker intends to recuperate her cash investment locked in the liquid that is still sitting in barrels.

Our study finds its motivation from a report provided by the London International Vintner's Exchange (Liv-ex shortly). In 2016, Liv-ex provided a report based on the price estimates of the world's largest 440 wine merchants. The report compared these wine merchant's prediction of the release price of the 2015 vintage wine futures with the actual release prices. The results were dramatic: These 440 leading wine merchants underestimated the release price of the 2015 vintage by a whopping 28%. The same report then showed the inability to estimate the release price of bottled wine. It was known at the time that the summer of 2015 provided a better growing condition, and the summer temperatures were significantly higher than those observed in 2014. Yet, for the 2014 vintage wines, the same leading 440 wine merchants were off in their predictions of bottled wine process by an average 46%. In sum, this report highlights the fact that the release price of both wine futures and bottled wine are neither explained easily, nor predicted accurately.

Our study presently focuses on the initial price of wine futures. It is well known that the price of wine futures changes from one vintage to another even for the same chateau or winemaker. We focus on the explaining factors in determining the initial wine futures price.

Our data comes from multiple sources. The data set features 44 of the leading 50 Bordeaux winemakers that make up the Liv-ex 500 index. Five winemakers are excluded because they are Sauternes producers and follow a different timeline. Another winemaker is excluded because it had multiple missing data points. Wine futures prices are obtained for the wine futures prices starting from the 2001 vintage until the 2016 vintage. Wine futures release price is collected through Liv-ex.com. The data regarding weather and rainfall belong to the statistics provided by the Merignac station representing the Bordeaux region in France. We also use the Liv-ex 100 index as a representative of the changes in the wine market conditions.

We examine weather fluctuations, rainfall during the summer, and market evolution in order to provide an explanation to the changes in wine futures from one vintage to another. We use the natural log-price change of wine futures prices between two consecutive vintages as the dependent variable. We use three explaining variables: (1) The difference between the average temperatures during the growing season of two consecutive vintages, (2) the difference between the total rainfall during the growing season of two consecutive vintages, and (3) the percentage change in the market condition, described by Liv-ex 100 index when compared with the value of the index from one year ago. It is important to note that the Liv-ex 100 index is composed of one hundred most sought after wines from earlier vintages; the winemakers that make up the index do not overlap with the wines in our data set.

Our analysis sheds light on the wine futures price from two perspectives: Explaining the movements in wine futures prices from one year to the next, and predicting the wine futures price before the announcement of release prices. Let us begin with the explaining power of our model. Using the above three explaining variables, we obtain a model that has an adjusted R2 value of 67%. All three explaining variables show statistical significance at the highest level of 1%. We find that an increase in the average temperature in the growing season of a vintage leads to a positive impact, increasing the release price of wine futures. The rainfall has a negative effect. An increase in the total rainfall during the growing season, when compared to the previous vintage's growing season, leads to a reduction in the release price of wine futures. The market conditions, represented by the value of the Liv-ex 100 index has a positive impact on the release price of wine futures. An increase in the value of Liv-ex 100 from one year ago leads to an increase in the release price of wine futures.

We next replicate our study in order to provide a robust prediction power. This time, rather than using the change

in the value of the Liv-ex 100 index from May to May, we regress the log-price changes in wine prices using the change in Liv-ex 100 between September (corresponding to the harvest time) to May (corresponding to the beginning of the growing season). Note that the Liv-ex 100 index value in September is eight months before wine futures are released. We conclude that these three variables lead to a respectable prediction power with a R^2 value exceeding 56%.

In conclusion, our study provides a statistically significant explanation about the release prices of wine futures. It develops a method with robust and respectable prediction power. Our study overall generates investor confidence as we get more accurate predictions of wine futures prices.